U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW-1 1965

A Record of Forest Plantings in Hawaii

Robert E. Nelson

Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

Contents

The Author

ROBERT E. NELSON is chief of the Station's Hawaii Research Center, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a bachelor's degree in forestry at the University of California. In 1946 he began working on the Station's forest survey of California. Three years later he became field supervisor of the State Cooperative Soil-Vegetation Survey, which is mapping and classifying upland soils and vegetation in California. Since 1957, he has been in charge of the Station's Hawaii office. This unit, in cooperation with the Hawaii Forestry Division, recently completed the first survey of the State's forest resources.

Few areas in the world have so many introduced plants as the Hawaiian Islands. Government agencies, private organizations, and many individuals have engaged in sometimes major efforts to bring in useful species. Introducing new species for forestry purposes began well before the turn of the century and is still continuing. Follow-up appraisal of the adaptability of introduced trees forms an important part of forestry research.

The Hawaii Forestry Division (and its predecessor agencies) has probably been the most active in tree introduction work. As early as 1887 Walker (1887) reported that "The Government Plantation on the hills between Makiki and Pauoa... now contains... about 200,000 trees of useful species which have by selection from a much larger number experimented upon, been cultivated as amongst those found to flourish in this climate...." In 1912, Ralph S. Hosmer, Superintendent of Forestry, emphasized: "An important phase of forest work in Hawaii is the introduction into the Territory of exotic trees of economic importance. This is a line of investigation that should receive much greater attention than has been given it in recent years" (Hawaii Board of Commissioners of Agriculture and Forestry 1912). In the same report he described some experimental plantings. Such tree introduction work has continued over the years; the Waiakea Arboretum in Hilo includes the latest major group of introduced species (Richmond 1963).

Many but not all of the introduced species have been appraised for forestry purposes. In 1886, Lubker (1886) wrote of *Acacia dealbata* and *A. pycnantha*: "...already it is plain, that there cannot be any other kinds of trees, which are better adapted to these islands for the purpose of Arbor culture...." Zschokke (1930) reviewed the adaptability and use of several species, mainly as windbreaks and for erosion control and fuelwood. Bryan (1947) made a significant contribution by rating the adaptability and use of most species introduced to the Big Island up to 1946. Carlson and Bryan (1959) provided detailed information about several important timber species.

No sustained efforts have been made to maintain organized records of all introductions throughout the Islands. Nor has an organized attempt been made to evaluate their adaptability on the many different sites in Hawaii. Among the many hundreds of introductions are possibly some valuable "sleepers." Similarly, some potentially valuable species that could and should be brought in have, no doubt, been overlooked.

Need for Appraisal

Plans for the initial Forest Survey in Hawaii pointed out the need for a systematic appraisal of past forest plantings, to gain full benefit from previous work and to guide future research[1]. This appraisal is now underway. Its objectives are to compile organized records of:

- Where and when each species was planted and the number planted.
- Adaptability of species as related to site factors.
- Suitability of tree species for timber production, based on growth, form, and wood quality.

The over-all purpose is to provide a reference to aid in selecting the best kinds of trees to grow for timber production and other forestry purposes on different sites in Hawaii. Underway is field appraisal of past plantings--the most important phase of this work.

Preparatory to the field work, we compiled available information about plantings made by the Hawaii Division of Forestry[2]. We extracted and coded information from three sources: (a) Card records maintained by the Hawaii Division of Forestry from 1917-1954; (b) monthly Forestry Division reports from 1954 to 1960; and (c) annual Forestry Division reports before 1917. Records and reports earlier than 1908 did not yield information useful for this compilation. Although introduced species have been favored in the plantings, several native species were also planted and we included these in our compilation. We included plants other than trees too, for as complete a record as possible.

Other agencies and individuals have records of tree plantings, but we have not yet tapped these sources.

Ideally we wanted accurate information on species identity, location of field plantings, number of seedlings planted, and dates of plantings. We recognized that the original records contain omissions, errors, and duplications. A serious handicap is the lack of information about precise locations of outplantings. Synonyms and errors in plant naming are troublesome. But the wealth of information available far outweighs any problems of extraction.

Arrangement of Data

The data obtained were transferred to punch cards from which two primary tabular listings have been compiled to guide and facilitate the actual species appraisal work.

One listing begins with the species Abelia chinensis, only two plants of which were planted. The next species in this listing is Aberia gardneri, a shrubby tree planted at 28 locations in 18 Forest Reserves.

---

[1]Nelson, Robert E. Plan for an initial survey of the timber resource in the Territory of Hawaii. 1958. (Unpublished report on file at Pacific SW. Forest & Range Expt. Sta., U. S. Forest Serv., Honolulu, Hawaii.)

[2]Most of the staff of the Forest Service's Forestry Research Center, Hawaii, participated to some degree in compiling this information. Roger G. Skolmen and Ronald M. Lanner extracted and coded most of the recorded information.

Between 1928 and 1941 a total of 16,088 plants of A. gardneri were planted. This list ends with Zizyphus jujuba, a small tree; 51 plants of this species were set out in only one location on Oahu in 1926. All told, nearly 1,100 species are listed as planted from 1908 to 1960. Of this total, about 800 are tree species; the balance are shrubs, vines, herbs, ferns, grasses, or palms. This listing also shows 136 plantings made, involving nearly 27,000 plants, in which the species are not identified.

Another arrangement of the data lists the plantings in each Forest Reserve. It shows for example, that 55 tree species and 2 shrub species have been planted in the Kalepa Reserve on the Island of Kauai. About 48,000 plants were set out in all in this Reserve between 1944 and 1958. This listing also shows that 1,198,000 plants have been set out in the Honolulu Forest Reserve.

From limited literature review and first hand knowledge, each listed species has been tentatively rated for probable silvical adaptability in Hawaii and for its use potential for wood products. These preliminary "value" ratings, as well as information on location and number of trees planted, provide the basis for screening species and selecting plantings for field appraisal.

We have gathered this information about the planting work of the Forestry Division primarily to enable us to evaluate and select the best tree species for forestry purposes in Hawaii. As information from field evaluations becomes available it will be reported. Meantime the information already compiled serves as a valuable reference for investigators and others in research. Part of this organized reference material is summarized in the appendix that follows.

Literature Cited

Bryan, L. W.
1947. Twenty-five years of forestry work on the island of Hawaii. Hawaiian Planters' Record 51(1):1-80, illus.

Carlson, Norman K., and Bryan, L. W.
1959. Hawaiian timber for the coming generations. 112 pp., illus. Honolulu: Trustees Bernice P. Bishop Estate.

Dalla Torre, C. G. de, and Harms, H.
1900-1907. Genera siphonogamarum ad systema englerianum conscripta, 568 pp. Leipzig: G. Engelman.

Hawaii Board of Commissioners of Agriculture and Forestry.
1912. Report for the biennial period ending December 31, 1912. pp. 73-76, Honolulu, Hawaii.

Lubker, F.
1886. The wattle trees. The Planters' Monthly (Hawaii) 6(9): 229-230.

Richmond, George B.
1963. Species trials at the Waiakea Arboretum, Hilo, Hawaii. U.S. Forest Serv. Res. Paper PSW-4, Pacific SW. Forest & Range Expt. Sta., Berkeley, Calif., 21 pp., illus.

Walker, Thomas R.
1887. Report of committee on forestry. The Planters' Monthly (Hawaii) 6(11):531-533.

Zchokke, Theodore C.
1930. A manual for tree planting in the Hawaiian Islands. Univ. Hawaii Agr. Ext. Serv. Ext. Bul. 5, 50 pp., illus.

Appendix

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1]

Genera[2/]	Family[3/]	No. of species	No. planted	Growth form[4/]
Abelia (Linnaea)	Caprifoliaceae	1	2	S
Aberia (Donyalis)	Flacourtiaceae	1	16,088	T,S
Abies	Pinaceae	5	359	T
Abutilon	Malvaceae	2	10	S
Acacia	Leguminosae	20	1,547,413	T,S
Acalypha	Euphorbiaceae	1	2	S
Acer	Aceraceae	4	361	T
Achras	Sapotaceae	1	300	T
Ackama	Cunoniaceae	1	89	T
Acoelorraphe	Palmae	1	3	P
Acrocarpus	Leguminosae	1	312	T
Actinidia	Dilleniaceae	1	2	S
Actinophloeus (Drymophloeus)	Palmae	1	3	P
Adansonia	Bombacaceae	1	188	T
Adenanthera	Leguminosae	1	1,406	T
Aegle	Rutaceae	1	12	T
Aesculus	Hippocastanaceae	1	7	T,S
Aframomum	Zingiberaceae	1	6	H
Afzelia	Leguminosae	1	1	T
Agathis	Pinaceae	4	2,228	T
Agave	Amaryllidaceae	1	1,600	S
Ailanthus	Simarubaceae	1	1,740	T
Ajuga	Labiatae	*	4	H
Albizia (Albizzia)	Leguminosae	14	303,795	T
Alectryon	Sapindaceae	1	1	T
Aleurites	Euphorbiaceae	3	16,433	T
Allamanda	Apocynaceae	1	214	S
Alnus	Betulaceae	5	44,113	T
Alocasia	Araceae	2	9	H
Alpinia	Zingiberaceae	2	140	H
Alyxia	Apocynaceae	1	10	V
Amoora	Meliaceae	2	43	T
Anacardium	Anacardiaceae	1	773	T
Andira	Leguminosae	1	40	T
Angiopteris	Marrattiaceae	1	1	F
Angophora	Myrtaceae	2	21,451	T
Anona	Anonaceae	5	821	T,S
Anthurium	Araceae	1	1	H
Antidesma	Euphorbiaceae	2	15	T
Aphanamixis	Meliaceae	2	32	T
Aphelandra	Acanthaceae	1	70	S
Aralia	Araliaceae	1	6	S

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera[2/]	Family[3/]	No. of species	No. planted	Growth form[4/]
Araucaria	Pinaceae	7	153,829	T
Arbutus	Ericaceae	1	8	T
Archontophoenix	Palmae	1	17	P
Ardisia	Myrsinaceae	2	251	S,T
Areca	Palmae	1	2	P
Arenga	Palmae	1	2	P
Argania	Sapotaceae	1	1	T
Argyroxiphium	Compositae	1	50	H
Artocarpus	Moraceae	5	2,749	T
Aspidistra	Liliaceae	1	16	H
Azalea	Ericaceae	1	307	S
Baccharis	Compositae	1	6	S
Bambusa	Gramineae	2	7,450	G
Baphia	Leguminosae	1	1	T
Barringtonia	Lecythidaceae	2	47	T
Bassia (Illipe)	Sapotaceae	1	1	T
Bauhinia	Leguminosae	14	716	T,S,V
Begonia	Begoniaceae	*	72	H
Beloperone	Acanthaceae	1	3	S
Betula	Betulaceae	1	30	T
Bidens	Compositae	1	4	H
Bignonia	Bignoniaceae	*	4	H
Bischofia	Euphorbiaceae	1	6,553	T
Bixa	Bixaceae	1	96	T
Blighia	Sapindaceae	1	9	T
Bocconia	Papaveraceae	1	4	S
Bombax	Bombacaceae	3	720	T
Bombycidendron (Hibiscus)	Malvaceae	2	263	T
Bougainvillea	Nyctaginaceae	*	11	S,V
Brachychiton	Sterculiaceae	5	4,399	T
Brassaia	Araliaceae	2	1,489	T
Brexia	Saxifragaceae	1	19	T
Breynia	Euphorbiaceae	1	24	S
Bridelia	Euphorbiaceae	2	382	T
Broussonetia	Moraceae	1	18	T
Brownea	Leguminosae	2	5	T
Bruguiera	Rhizophoraceae	1	133	T
Bucida	Combretaceae	1	2	T
Bucklandia	Hamamelidaceae	1	8	T
Bumelia	Sapotaceae	1	2,791	T
Butea	Leguminosae	1	152	T
Cactus	Cactaceae	*	2	H
Caesalpinia	Leguminosae	2	208	T,S
Calamus	Palmae	1	2	P

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera[2/]	Family[3/]	No. of species	No. planted	Growth form[4/]
Calliandra	Leguminosae	2	63	S
Callicarpa	Verbenaceae	1	17	S
Callistemon	Myrtaceae	2	3,105	S,T
Callitris	Pinaceae	7	6,183	T
Calocarpum (Lucuma)	Sapotaceae	1	2	T
Calodendrum	Rutaceae	1	56	T
Calophyllum	Guttiferae	5	1,751	T
Calotropis	Asclepiadaceae	1	16	S
Calpurnia	Leguminosae	1	2	S
Calycophyllum	Rubiaceae	1	11	T
Camellia (Thea)	Theaceae	3	30	S
Cananga (Canangium)	Anonaceae	1	41	T
Canarium	Burseraceae	3	24	T
Canthium (Plectronia)	Rubiaceae	1	227	S
Carica	Caricaceae	1	103	T,S
Carludovica	Cyclanthaceae	1	358	S
Carya	Juglandaceae	3	514	T
Caryota	Palmae	1	6	P
Casimiroa	Rutaceae	1	460	T
Cassia	Leguminosae	16	3,436	T,S
Castanea	Fagaceae	5	650	T,S
Castanospermum	Leguminosae	1	1,187	T
Castilla (Castilloa)	Moraceae	1	42	T
Casuarina	Casuarinaceae	13	1,136,217	T
Catalpa	Bignoniaceae	3	3,621	T
Cavanillesia	Bombacaceae	1	56	T
Cecropia	Moraceae	1	752	T
Cedrela	Meliaceae	3	3,549	T
Cedrus	Pinaceae	1	102	T
Ceiba	Bombacaceae	1	1,662	T
Celtis	Ulmaceae	2	2	T,S
Centrolobium	Leguminosae	1	1	T
Ceodes (Pisonia)	Nyctaginaceae	1	4	T
Ceratonia	Leguminosae	1	9	T
Cerbera	Apocynaceae	1	3	T
Cercis	Leguminosae	1	42	T
Cestrum	Solanaceae	2	235	S
Chaenomeles (Cydonia)	Rosaceae	1	1	S
Chamaecyparis	Pinaceae	5	56,656	T
Chamaedorea	Palmae	1	10	P
Chamaefistula (Cassia)	Leguminosae	1	1	T,S
Charpentiera	Amarantaceae	1	3	T,S
Chiranthodendron	Sterculiaceae	1	5	T
Chorisia	Bombacaceae	1	4	T

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera[2]	Family[3]	No. of species	No. planted	Growth form[4]
Chrysalidocarpus (Hyophorbe)	Palmae	1	61	P
Cibotium	Cyatheaceae	1	27	F
Cinnamomum	Lauraceae	3	5,116	T
Cipadessa	Meliaceae	*	20	S
Citharexylum	Verbenaceae	1	367	T
Citrullus	Cucurbitaceae	1	26	V
Citrus	Rutaceae	*	8,798	T,S
Cladium	Cyperaceae	1	230	H
Claoxylon	Euphorbiaceae	1	1	S
Clematis	Ranunculaceae	*	2	V
Clerodendron	Verbenaceae	2	1,894	T,S
Clusia	Guttiferae	1	60	T
Coccoloba	Polygonaceae	1	995	T,S
Cochlospermum	Cochlospermaceae	1	83	T
Cocos	Palmae	*	25,452	P
Coelococcus	Palmae	1	17	P
Coffea	Rubiaceae	2	366	T,S
Colensoa (Pratia)	Campanulaceae	1	6	H
Colubrina	Rhamnaceae	2	2,436	T,S
Colutea	Leguminosae	1	27	S
Colvillea	Leguminosae	1	1	T
Congea	Verbenaceae	1	2	S
Conocarpus(Leucadendron)	Proteaceae	1	84	T,S
Copaifera	Leguminosae	1	46	T
Coprosma	Rubiaceae	*	1	S
Cordia	Borraginaceae	10	2,844	T
Cordyline	Liliaceae	2	118,460	H,S
Cornus	Cornaceae	1	4	T,S
Corylus	Betulaceae	2	14	S
Corynocarpus	Corynocarpaceae	1	5,145	T
Costus	Zingiberaceae	1	24	S
Cotoneaster	Rosaceae	4	150	S
Crescentia	Bignoniaceae	1	2,290	T
Cryptomeria	Pinaceae	1	499,306	T
Cryptostegia	Asclepiadaceae	1	233	V,S
Cunninghamia	Pinaceae	1	11,040	T
Cupressus	Pinaceae	12	254,273	T
Cuscuta	Convolvulaceae	1	287	V
Cyanea	Campanulaceae	2	8	S
Cydonia	Rosaceae	1	29	T
Cynometra	Leguminosae	1	100	T,S
Cyperus	Cyperaceae	1	9	G
Cyphomandra	Solanaceae	1	12	S
Dacrydium	Taxaceae	1	4	T

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera[2/]	Family[3/]	No. of species	No. planted	Growth form[4/]
Dalbergia	Leguminosae	3	588	T
Datura	Solanaceae	1	1	S
Deguelia (Derris)	Leguminosae	*	*	*
Dendrocalamus	Gramineae	1	36	G
Desmoncus	Palmae	1	2	P
Dieffenbachia	Araceae	*	24	H
Dillenia	Dilleniaceae	1	21	T
Diospyros	Ebenaceae	5	718	T,S
Diplotropis	Leguminosae	1	25	T
Dipterocarpus	Dipterocarpaceae	1	1	T
Dodonaea	Sapindaceae	2	4,115	S
Dolichandrone	Bignoniaceae	2	408	T
Dombeya	Sterculiaceae	*	1	T,S
Duranta	Verbenaceae	1	153	S
Durio	Malvaceae	1	7	T
Elaeocarpus	Elaeocarpaceae	1	36	T
Elaeodendron	Celastraceae	1	86	T,S
Entandrophragma	Meliaceae	1	224	T
Enterolobium	Leguminosae	1	16,067	T
Eranthemum	Acanthaceae	1	2	S
Eriobotrya	Rosaceae	1	826	T
Eriogonum	Polygonaceae	1	16	S
Erythrina	Leguminosae	8	7,455	T, S
Eucalyptus	Myrtaceae	89	4,220,996	T,S
Eugenia	Myrtaceae	8	49,002	T,S
Euphorbia	Euphorbiaceae	2	14	S,H
Euphoria (Nephelium)	Sapindaceae	2	424	T
Eurya	Theaceae	1	2,100	T,S
Euterpe	Palmae	1	2	P
Fagraea	Loganiaceae	1	438	T
Feijoa (Orthostemon)	Myrtaceae	1	10	S
Ficus	Moraceae	36	128,694	T,S
Filicium	Sapindaceae	1	6	T
Firmiana	Sterculiaceae	1	1	T
Fitchia	Compositae	1	181	T
Flindersia	Rutaceae	3	4,093	T
Fortunella	Rutaceae	2	7	S
Fraxinus	Oleaceae	5	686,893	T
Galphimia	Malpighiaceae	1	71	S
Garcinia	Guttiferae	4	28	T
Gardenia	Rubiaceae	5	399	T,S
Gaussia	Palmae	1	2	P
Ginkgo	Ginkgoaceae	1	20	T
Gleditsia	Leguminosae	1	20	T

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera [2/]	Family [3/]	No. of species	No. planted	Growth form [4/]
Gliricidia	Leguminosae	2	2,075	T,S
Gossypium	Malvaceae	4	323	S
Grevillea	Proteaceae	1	2,242,027	T
Grewia	Tiliaceae	1	100	T,S
Guaiacum	Zygophyllaceae	1	1,081	T
Guazuma	Sterculiaceae	1	394	T
Guilielma (Bactris)	Palmae	1	1	P
Gynocardia	Flacourtiaceae	1	766	T
Haematoxylon	Leguminosae	1	107,729	T
Hakea	Proteaceae	1	26	S
Harpullia	Sapindaceae	3	1,984	T
Hedera	Araliaceae	1	4	S
Hedychium	Zingiberaceae	1	650	H
Helianthus	Compositae	1	45	H
Hevea	Euphorbiaceae	1	51	T
Hibiscus	Malvaceae	8	8,027	T,S
Holmskioldia	Verbenaceae	1	2	S
Hopea	Dipterocarpaceae	3	3	T
Hovenia	Rhamnaceae	1	1	T
Hydnocarpus	Flacourtiaceae	4	10,207	T
Hymenaea	Leguminosae	1	12	T
Hymenosporum	Pittosporaceae	1	4	T
Hyophorbe	Palmae	1	6	P
Idesia	Flacourtiaceae	1	2	T
Ilex	Aquifoliaceae	5	268	T,S
Inga	Leguminosae	1	85	T
Intsia	Leguminosae	1	285	T
Ipomoea	Convolvulaceae	1	3	V
Ixora	Rubiaceae	3	9	S
Jacaranda	Bignoniaceae	1	7,166	T
Jacquinia	Theophrastaceae	*	11	T
Juglans	Juglandaceae	4	1,898	T,S
Juniperus	Pinaceae	6	7,687	T,S
Khaya	Meliaceae	2	115	T
Kigelia	Bignoniaceae	1	137	T
Kleinhovia	Sterculiaceae	1	14	T
Koelreuteria	Sapindaceae	2	447	T
Kokia	Malvaceae	*	297	T
Lagerstroemia	Lythraceae	5	5,219	T,S
Lagunaria	Malvaceae	1	6	T
Larix	Pinaceae	2	24	T
Latania	Palmae	1	6	P
Lecythis	Lecythidaceae	4	567	T
Leea	Vitaceae	1	1	S

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera 2/	Family 3/	No. of species	No. planted	Growth form 4/
Leptospermum	Myrtaceae	4	1,553	S
Lespedeza	Leguminosae	1	250	S
Leuceria	Compositae	1	3	*
Libocedrus	Pinaceae	1	631	T
Ligularia	Compositae	1	13	H
Linociera	Oleaceae	1	10,614	T
Lippia	Verbenaceae	1	28	S
Litchi	Sapindaceae	1	46	T
Lonicera	Caprifoliaceae	*	31	S,V
Lucuma	Sapotaceae	2	23	T
Luffa	Cucurbitaceae	1	4	V
Lupinus	Leguminosae	1	23	S
Lysiloma	Leguminosae	2	727	T
Macadamia	Proteaceae	1	20,411	T
Macaranga	Euphorbiaceae	3	545	T
Machaerium	Leguminosae	1	2,246	T
Maclura	Moraceae	1	229	T
Magnolia	Magnoliaceae	3	11	T
Malpighia	Malpighiaceae	1	14	S
Malus (Pirus)	Rosaceae	*	101	T
Mammea	Guttiferae	1	101	T
Mandevilla	Apocynaceae	1	2	S
Mangifera	Anacardiaceae	2	2,445	T
Manihot	Euphorbiaceae	1	24	S
Markhamia	Bignoniaceae	1	47	T
Martinezia	Palmae	1	2	P
Melaleuca	Myrtaceae	8	1,737,323	T,S
Melia	Meliaceae	1	46,186	T
Melicocca	Sapindaceae	1	30	T
Melochia	Sterculiaceae	2	5,705	T
Mesembrianthemum	Aizoaceae	*	52	H
Metasequoia	Pinaceae	1	39	T
Metrosideros	Myrtaceae	3	139	T
Mezoneuron (Mezoneurum)	Leguminosae	1	81	T
Millettia	Leguminosae	1	2	T
Mimosa	Leguminosae	1	111	T
Mimusops	Sapotaceae	2	1,900	T
Monstera	Araceae	1	87	V
Montezuma (Thespesia)	Malvaceae	1	24	T
Montrichardia	Araceae	1	4	S
Morinda	Rubiaceae	1	6	T
Moringa	Moringaceae	1	425	T
Morus	Moraceae	4	17,981	T
Mucuna	Leguminosae	1	1	V
Muntingia	Elaeocarpaceae	1	149	T

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera [2]	Family [3]	No. of species	No. planted	Growth form [4]
Murraya	Rutaceae	1	1,126	S
Musa	Musaceae	*	36	H
Musanga	Moraceae	1	7	T
Myoporum	Myoporaceae	1	16,723	T
Myrica	Myricaceae	3	2,695	T,S
Myrospermum	Leguminosae	1	20	T,S
Myroxylon	Leguminosae	1	970	T
Myrsine	Myrsinaceae	*	219	T,S
Neowawraea	Euphorbiaceae	1	28	T
Nerium	Apocynaceae	2	14	S
Nesoluma (Chrysophyllum)	Sapotaceae	1	7,029	T
Noronhia	Oleaceae	1	8,961	T
Nothocestrum	Solanaceae	*	2	T,S
Nyssa	Cornaceae	1	4	T
Ochna	Ochnaceae	1	2	S
Ochroma	Bombacaceae	1	1,471	T
Ochrosia	Apocynaceae	2	7	T
Olea	Oleaceae	2	1,810	T,S
Olneya	Leguminosae	1	30	T
Omphalea	Euphorbiaceae	1	2	*
Oncoba	Flacourtiaceae	2	20	T,S
Oreodoxa	Palmae	1	24	P
Ormosia	Leguminosae	1	12	T
Osmanthus	Oleaceae	1	181	T
Osteomeles	Rosaceae	1	504	S
Pachira (Bombax)	Bombacaceae	2	23	T
Pahudia	Leguminosae	1	128	T
Palaquium	Sapotaceae	1	16	T
Palagea (Palovea)	Leguminosae	1	25	T
Panax	Araliaceae	*	2	S
Pandanas	Pandanaceae	2	26,442	T
Parinarium	Rosaceae	1	1	T
Passiflora	Passifloraceae	1	14	V
Paulownia	Scrophulariaceae	1	206	T
Pelea	Rutaceae	*	10	T
Peltophorum	Leguminosae	1	10,154	T
Persea	Lauraceae	1	57,374	T
Phaeomeria	Zingiberaceae	1	153	H
Philadelphus	Saxifragaceae	1	2	S
Philodendron	Araceae	*	25	H,V
Phoenix	Palmae	*	34	P
Phormium	Liliaceae	1	718	H
Photinia	Rosaceae	2	166	S

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera 2/	Family 3/	No. of species	No. planted	Growth form 3/
Phyllocarpus	Leguminosae	1	4	T
Physalis	Solanaceae	1	18	H
Picea	Pinaceae	5	2,615	T
Pimenta	Myrtaceae	1	2,432	T
Pinanga	Palmae	1	8	P
Pinus	Pinaceae	46	437,588	T
Piper	Piperaceae	2	1,820	S
Piptadenia	Leguminosae	1	50	T
Pipturus	Urticaceae	*	10	T,S
Piscidia	Leguminosae	1	86	T
Pisonia	Nyctaginaceae	1	6	S
Pistacia	Anacardiaceae	*	25	T
Pithecellobium	Leguminosae	2	802	T
Pittosporum	Pittosporaceae	3	114	T,S
Plagianthus	Malvaceae	1	25	*
Planchonella (Sideroxylon)	Sapotaceae	1	2	T
Platanus	Platanaceae	2	521	T
Platymiscium	Leguminosae	2	5,597	T
Pleomele (Dracaena)	Liliaceae	2	723	T
Plumeria (Plumiera)	Apocynaceae	*	227	S
Podocarpus	Taxaceae	5	596	T
Poinciana (Delonix)	Leguminosae	1	173	T
Polyalthia	Anonaceae	1	55	T
Polygonum	Polygonaceae	*	2	S,V
Pometia	Sapindaceae	1	3	T
Pongamia	Leguminosae	3	90	T
Populus	Salicaceae	2	22	T
Posoqueria	Rubiaceae	1	247	T
Pothos	Araceae	1	1,083	V
Pritchardia	Palmae	*	1,092	P
Prosopis	Leguminosae	1	70	T
Prunus	Rosaceae	*	7,271	T
Pseudomorus	Moraceae	1	1	T,S
Pseudotsuga	Pinaceae	1	1,835	T
Psidium	Myrtaceae	3	26,840	T,S
Pteralyxia	Apocynaceae	1	35	T
Pterocarpus	Leguminosae	6	1,167	T
Ptychosperma	Palmae	*	151	P
Punica	Punicaceae	1	211	T,S
Pyracantha (Cotoneaster)	Rosaceae	2	338	S
Pyrus (Pirus)	Rosaceae	2	124	T
Quercus	Fagaceae	7	2,398	T
Rauwolfia	Apocynaceae	1	2	T
Ravenala	Musaceae	1	24	P

See footnotes at end of table.

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera [2]	Family [3]	No. of species	No. planted	Growth form [4]
Reynoldsia	Araliaceae	1	20	T
Rhamnus	Rhamnaceae	1	146	S
Rhododendron	Ericaceae	2	145	S
Rhus	Anacardiaceae	2	38	T,S
Ricinus	Euphorbiaceae	*	20	S
Robinia	Leguminosae	1	2,215	T
Rubus	Rosaceae	*	98	S
Sabal	Palmae	*	1,567	P
Salix	Salicaceae	3	130	T,S
Samanea (Pithecellobium)	Leguminosae	1	24,566	T
Sambucus	Caprifoliaceae	*	801	T
Sandoricum	Meliaceae	1	3,545	T
Santalum	Santalaceae	2	20,655	T,S
Sapindus	Sapindaceae	2	2,305	T
Sapium	Euphorbiaceae	1	8	T
Saraca	Leguminosae	1	1	T
Saxifraga	Saxifragaceae	1	2	H
Scaevola	Goodeniaceae	*	442	S
Scheelea (Attalea)	Palmae	1	1	P
Schinus	Anacardiaceae	2	13,759	T,S
Schotia	Leguminosae	1	1	T
Sequoia	Pinaceae	2	130,474	T
Sesbania	Leguminosae	2	1,121	T,S
Sicana	Cucurbitaceae	1	4	V
Sida	Malvaceae	*	2	S
Sideroxylon	Sapotaceae	1	1	T
Solanum	Solanaceae	8	1,675	T,H,S
Sophora	Leguminosae	4	514	T,S
Spathodea	Bignoniaceae	1	30,536	T
Spondias	Anacardiaceae	3	7,163	T
Stemmadenia	Apocynaceae	1	3	T
Stenocarpus	Proteaceae	1	2	T
Sterculia	Sterculiaceae	1	22	T
Straussia	Rubiaceae	*	24	T,S
Strelitzia	Musaceae	1	8	H
Streptosolen	Solanaceae	1	2	S
Strophanthus	Apocynaceae	*	4	S
Styphelia	Epacridaceae	1	10	S
Swietenia	Meliaceae	2	20,009	T
Syncarpia	Myrtaceae	2	99,358	T
Syzigium	Myrtaceae	1	143	T
Tabebuia (Tecoma, Cybistax)	Bignoniaceae	6	1,304	T
Tabernaemontana	Apocynaceae	*	1	S
Tamarindus	Leguminosae	1	1,235	T

See footnotes at end of table

Table 1.--Forest plantings in Hawaii by genera, 1908-1960[1], continued

Genera[2/]	Family[3/]	No. of species	No. planted	Growth form[4/]
Tarrietia	Sterculiaceae	1	1	T
Tecoma (Tabebuia)	Bignoniaceae	5	5,946	T,S
Tetraplasandra	Araliaceae	*	8	S
Tetrazygia	Melastomataceae	1	8	*
Themeda	Graminae	*	201	G
Theobroma	Sterculiaceae	1	114	T
Thespesia	Malvaceae	1	10,647	T
Thevetia	Apocynaceae	2	5	S
Thrinax	Palmae	1	2	P
Thuja	Pinaceae	4	78,994	T
Tibouchina	Melastomataceae	3	1,007	S
Toona	Meliaceae	2	190,004	T
Tournefortia	Borraginaceae	1	1,376	T,S
Toxylon (Maclura)	Moraceae	1	8	T,S
Trachylobium	Leguminosae	1	41	T
Trema	Ulmaceae	2	31,462	T
Triplaris	Polygonaceae	1	274	T
Tristania	Myrtaceae	1	396,177	T
Tsuga	Pinaceae	2	21	T
Typha	Typhaceae	1	151	H
Ulmus	Ulmaceae	4	6,703	T
Vaccinium	Ericaceae	1	91	S
Veronica	Scrophulariaceae	1	172	H
Virgilia	Leguminosae	1	270	T
Vitex	Verbenaceae	5	10,619	T,S
Vitis	Vitaceae	*	82	S
Wallaceodendron	Leguminosae	1	1	T
Warszewiczia	Rubiaceae	1	167	S
Wikstroemia	Thymelaeaceae	*	396	S
Wilkesia	Compositae	1	142	S
Wormia (Dillenia)	Dilleniaceae	1	2	S
Wrightia	Apocynaceae	1	2	S
Xanthorrhoea	Liliaceae	1	20	H
Xylia	Leguminosae	1	66	T
Xylosma	Flacourtiaceae	*	4	T
Yucca	Liliaceae	1	12	T
Zizyphus	Rhamnaceae	1	51	T
Unidentified (Canal Zone)	*	1	15	*
Unidentified (Tongatabu #9530)	*	1	9	*

[1]Plantings of record by the Hawaii Division of Forestry.

[2]Recorded names have been corrected in cases of obvious error, and synonyms are provided to help identify some plantings.

[3]Dalla Torre and Harms (1900-1907) is the primary source of family names.

[4]T = tree, S = shrub, P = palm or palm-like, G = grass, V = vine, H = herb, F = fern.

*Not identified.

Table 2.--Tree species planted in Hawaii forests in numbers greater than 10,000, 1908-1960[1]

Species	Number planted
	Thousand
Aberia gardneri	16
Acacia confusa	295
Acacia decurrens	65
Acacia decurrens var. dealbata	24
Acacia koa	1,137
Acacia melanoxylon	17
Albizia lebbekoides	10
Albizia moluccana (falcata)	138
Albizia montana	145
Aleurites moluccana	16
Alnus nepalensis	43
Angophora lanceolata	20
Araucaria cookii	22
Araucaria excelsa	123
Casuarina cunninghamia	13
Casuarina equisetifolia	70
Casuarina glauca	998
Casuarina montana	32
Casuarina stricta	11
Cedrela odorata	26
Chamaecyparis lawsoniana	52
Cryptomeria japonica	499
Cunninghamia lanceolata	11
Cupressus arizonica	10
Cupressus macrocarpa	216
Enterolobium cyclocarpum	16
Eucalyptus camaldulensis	429
Eucalyptus citriodora	127
Eucalyptus deanei	30
Eucalyptus maideni	36
Eucalyptus marginata	17
Eucalyptus microcorys	102
Eucalyptus paniculata	138
Eucalyptus pilularis	121
Eucalyptus racemosa	33
Eucalyptus resinifera	91
Eucalyptus robusta	2,321
Eucalyptus rudis	34
Eucalyptus saligna	437
Eucalyptus sideroxylon	151
Eucalyptus stuartiana[2]	30
Eucalyptus umbellata (tereticornis)	53
Eugenia cumini	11
Eugenia jambos	29
Ficus macrophylla	37
Ficus nota	25
Ficus rubiginosa	40
Fraxinus americana[3]	386
Fraxinus uhdei	74
Grevillea robusta	2,242
Haematoxylon campechianum	108
Heliocarpus americanus	25
Macadamia ternifolia	20
Melaleuca leucadendron	1,733
Melia azedarach	46
Morus nigra	16
Myoporum sandwicense	17
Peltophorum inerme	10
Persea americana	57
Pinus caribaea	27
Pinus elliottii	64
Pinus patula	15
Pinus pinaster	173
Pinus radiata	121
Psidium littorale	27
Samanea (Pithecellobium) saman	25
Santalum album	20
Sequoia sempervirens	130
Spathodea campanulata	31
Swietenia mahagoni	13
Syncarpia hillii	16
Syncarpia laurifolia	83
Taxodium distichum	42
Taxodium mucronatum	17
Terminalia myriocarpa	26
Thespesia populnea	11
Thuja plicata	76
Toona ciliata var. australis	190
Trema orientalis	31
Tristania conferta	396

[1]Plantings of record by the Hawaii Division of Forestry.

[2]Probably mostly *E. robusta*.

[3]Probably mostly *F. uhdei*.

Table 3.--Forest plantings in Hawaii by family[1], 1908-1960[2]

Family	Number of genera planted	Family	Number of genera planted
Cyatheaceae	1	Hamamelidaceae	1
Marrattiaceae	1	Platanaceae	1
Ginkgoaceae	1	Rosaceae	12
Taxaceae	2	Leguminosae	69
Pinaceae	20	Zygophyllaceae	1
Typhaceae	1	Rutaceae	8
Pandanaceae	1	Simarubaceae	1
Gramineae	3	Burseraceae	1
Cyperaceae	2	Meliaceae	10
Palmae	26	Malpighiaceae	2
Cyclanthaceae	1	Euphorbiaceae	15
Araceae	7	Anacardiaceae	6
Liliaceae	6	Corynocarpaceae	1
Amaryllidaceae	1	Aquifoliaceae	1
Musaceae	3	Celastraceae	1
Zingiberaceae	5	Aceraceae	1
Casuarinaceae	1	Hippocastanaceae	1
Piperaceae	1	Sapindaceae	11
Salicaceae	2	Rhamnaceae	4
Myricaceae	1	Vitaceae	2
Juglandaceae	2	Elaeocarpaceae	2
Betulaceae	3	Tiliaceae	1
Fagaceae	2	Malvaceae	11
Ulmaceae	3	Bombacaceae	7
Moraceae	10	Sterculiaceae	10
Urticaceae	1	Dilleniaceae	3
Proteaceae	5	Ochnaceae	1
Santalaceae	1	Theaceae	2
Polygonaceae	4	Guttiferae	4
Amarantaceae	1	Dipterocarpaceae	2
Nyctaginaceae	3	Bixaceae	1
Ranunculaceae	1	Cochlospermaceae	1
Magnoliaceae	1	Flacourtiaceae	6
Anonaceae	3	Passifloraceae	1
Lauraceae	2	Caricaceae	1
Papaveraceae	1	Begoniaceae	1
Moringaceae	1	Cactaceae	1
Saxifragaceae	3	Thymelaeaceae	1
Pittosporaceae	2	Lythraceae	1
Cunoniaceae	1	Punicaceae	1

See footnotes at end of table.

Table 3.--Forest plantings in Hawaii by family[1], 1908-1960[2], continued

Family	Number of genera planted	Family	Number of genera planted
Lecythidaceae	2	Labiatae	1
Rhizophoraceae	1	Solanaceae	7
Combretaceae	1	Scrophulariaceae	2
Myrtaceae	13	Bignoniaceae	10
Melastomataceae	2	Acanthaceae	3
Araliaceae	6	Myoporaceae	1
Cornaceae	1	Rubiaceae	10
Ericaceae	4	Caprifoliaceae	3
Epacnidaceae	1	Cucurbitaceae	3
Theophrastaceae	1	Campanulaceae	2
Myrsinaceae	2	Goodeniaceae	1
Sapotaceae	11	Compositae	9
Ebenaceae	1		
Oleaceae	5		
Loganiaceae	1		
Apocynaceae	14		
Asclepiadaceae	2		
Convolvulaceae	2		
Borraginaceae	2		
Verbenaceae	8		

[1]Families in order according to the Natural System of Classification of Engler (Dalla Torre and Harms 1900-1907).

[2]Plantings of record by the Hawaii Division of Forestry.

Addendum: Additional plantings of record to supplement Table 1

Genera	Family	No. of species	No. planted	Growth form
Chrysobalanus	Rosaceae	1	25	S
Chrysophyllum	Sapotaceae	1	455	T
Cinchona	Rubiaceae	5	6,880	T
Heliocarpus	Tiliaceae	1	24,666	T
Heritiera	Sterculiaceae	1	5	T
Hibiscadelphus	Malvaceae	1	34	T
Mahonia (Berberis)	Berberidaceae	1	9	S
Tamarix	Tamaricaceae	1	166	S
Taxodium	Pinaceae	2	58,801	T
Tectona	Verbenaceae	1	2,186	T
Tephrosia	Leguminosae	1	347	S
Terminalia	Combretaceae	7	27,725	T
Washingtonia	Palmae	1	3	P
Widdringtonia (Callitris)	Pinaceae	1	35	T

GPO 970-989

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 2 1965

Timber Harvest in California, 1962

G. F. Muerle and E. M. Hornibrook

Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

CONTENTS

The Authors

GERHARD F. MUERLE joined the Station's Forest Survey staff in 1963, after administrative and forest management assignments in California and Oregon. He holds a bachelor's degree in forestry from the University of California (1951). EZRA M. HORNIBROOK is in charge of the Forest Survey at this Station. He came to the Berkeley staff in 1949 after assignments at the Rocky Mountain and Southwestern Experiment Stations and on the National Forests in Washington, Arizona, and New Mexico. He is a 1928 forestry graduate of Oregon State University.

Foreword

In 1963, the Pacific Southwest Forest and Range Experiment Station conducted a survey of 1962 timber products output in California. This paper reports the results for primary wood products--roundwood logs and bolts.

This kind of survey, a part of the nationwide Forest Survey, is conducted about every five years. The 1947 survey, covering 1946 output, was the first in the series. Other surveys were made in 1952 and 1957.

The information collected on timber products output is combined with information on woods residues to provide an estimate of total timber cut. This, in turn, is analyzed with data on timber inventory and growth in reviewing the State and national timber outlook. Statistics of timber products output provide information valuable to the timber industry, state and county planning commissions, economists, foresters, and others concerned with the formation of forestry programs and policies.

Many individuals and companies of California's timber industry contributed information for use in this report. The industry trade associations gave their support. Numerous persons in the California Division of Forestry and on the National Forests helped to bring the Station's industry mailing lists up to date. All of this assistance is gratefully acknowledged.

Grateful acknowledgement is also made to colleagues for assistance in numerous ways; particular mention is due W. Y. Pong for making the questionnaire canvass, to D. D. Oswald for field contacts, to R. C. Chapman for programing computer data processing, to members of the Pacific Southwest Station's data processing section for key punching and processing data, and to J. D. Kasile for checking statistics.

California's harvest of timber products[1] in 1962 was second highest in the United States. This production constituted nearly 10 percent of the total national cut from growing stock. Only Oregon produces more. Washington runs a close third.

Timber is cut in California for many forest products, including sawlogs, peeler logs, pulpwood, fence posts, grapestakes, shingles, shakes, crossties, poles, piling, posts, mine timbers, charcoal, and fuelwood. Although many timber commodities are produced, for many years 98 percent or more of the total timber cut in the State has gone into sawlog and peeler log production. Only 2 percent goes into all other products. Since 1956 the proportion of the total cut used for peeler logs has increased from 7.6 to 13.1 percent and sawlog production has suffered a corresponding decline.

The timber harvest, by products, in 1962 was as follows (see also table 1, appendix):

	Timber harvest	
Product:	(MMBF)	(Percent)
Sawlogs	4,752	85.3
Veneer logs and bolts	728	13.1
Split products	25	.4
Fuelwood	27	.5
Pulpwood	22	.4
Poles	10	.2
Shingle and shake logs and bolts	3	.1
Piling	2	(2/)
Mine timbers	1	(2/)
Round posts	(1/)	(2/)
Total	5,570	100.0

1/ 112 thousand board feet, equivalent.
2/ Less than 0.1 percent.

Species harvested.--Douglas-fir led all species in total output--some 2.1 billion board feet were harvested. Redwood and ponderosa pine each had less than half the production of Douglas-fir and were close together in second and third places, respectively. These were followed by true firs,

[1] The terms ''timber harvest,'' ''timber cut,'' ''timber production,'' and ''timber products output'' are used synonymously in this report in referring to the net volume of roundwood removed from the forest for manufacture or use. These terms do not include inventory volume left on the ground as woods residue after logging, nor do they refer to the product manufactured from logs, i.e., lumber.

fourth; and sugar pine, fifth. The cut of hardwoods is negligible, amounting to only 1 percent of the total. The harvest, by species, in 1962 was as follows (see also table 1, appendix):

	Timber harvest (MMBF)	Timber harvest (Percent)
Species:		
Douglas-fir	2,134	38
Redwood	939	17
Ponderosa and Jeffrey pine	881	16
True firs	857	15
Sugar pine[1]	399	7
Other softwoods	174	3
Hardwoods	26	1
Undistributed[2]	160	3
Total	5,570	100

[1]Includes western white pine.

[2]Estimate for nonreporting operators plus volumes reported without species breakdown.

Where timber was cut.--California's timber industry is concentrated in the northern part of the State. In 1962 southern Californi accounted for only six-tenths of 1 percent of the timber harvest. Southern California in this case is considered to include all counties south of the east-west line formed by the northern boundaries of San Luis Obispo, Kern, and San Bernardino counties.

Counties in the redwood belt together produced 44 percent of the State's total cut. Three of the highest-producing five counties were from this region. Humboldt County led all others with 25 percent of the total timber harvest. In 1962, counties ranked as follows in timber production (see also table 2, appendix):

Rank	County	Timber harvest (MMBF)	Timber harvest (Percent)
1	Humboldt	1,396	25.1
2	Mendocino	605	10.9
3	Shasta	386	6.9
4	Siskiyou	373	6.7
5	Del Norte	302	5.4
6	Trinity	291	5.2
7	Plumas	206	3.7
8	El Dorado	184	3.3
9	Lassen	148	2.7
10	Tehama	146	2.6
	All others	[1]1,533	27.5
	Total	5,570	100.0

[1]Includes volume of all products for which county of origin was not reported and estimates for nonreporting operators.

Timber Products Output

Sawlogs and peeler logs in particular deserve detailed attention because they compose so large a share (85 and 13 percent, respectively) of total timber products output. Additional details are also given for other products. The appendix in this report provides information on survey procedures and includes tables 1 to 18.

Sawlogs

During 1962, the California harvest of sawlogs amounted to nearly 4.8 billion board feet--85.3 percent of the total output of roundwood. Douglas-fir, the favored species, accounted for 32.2 percent of sawlog volume. Other species of major importance to the sawmill industry were ponderosa and Jeffrey pine, redwood, true firs, and white pines. These species along with Douglas-fir together accounted for nearly 94 percent of the volume cut. Hardwoods were rarely cut for sawlogs and then only for specialty mills in one part of the State. Only one-tenth of 1 percent of sawlog volume came from hardwood species. Sawlog production in 1962, by species group, was as follows (see also table 3, appendix):

	Sawlog production	
Species group:	(MMBF)	(Percent of reported volume)
Douglas-fir	1,488	32.2
Redwood	907	19.6
Ponderosa and Jeffrey pine	858	18.6
True firs[1]	798	17.3
Sugar pine[2]	394	8.5
Western hemlock	4	.1
Sitka spruce	5	.1
Other softwoods	161	3.5
Hardwoods	4	.1
Total, reporting operators	4,619	100.0
Estimate for nonreporting operators	133	
Total	4,752	

[1]Includes white, red, and grand fir.

[2]Includes western white pine.

Number and Size of Mills

Most of California's sawlog output was delivered to California mills. Only 2.7 percent of the harvested volume was exported (table 4, appendix). Most of the exported logs went to mills in southern Oregon and Nevada. Some went to the Orient.

In 1962, there were 297 known active sawmills in California and 64 mills in operable condition but known to be idle. For ease of comparison, active mills were grouped according to volume of sawlogs received. The industry's largest mills--that is, those with annual receipts exceeding 25 million board feet--accounted for 59 percent of the total sawlog receipts in the State. Only 21 percent of the reporting mills were in this size-class. On the other end of the scale, 12 percent of California's sawmills had log receipts of 1 million board feet or less during 1962. Mills in this size-class received a mere 0.2 percent of the total. Size of mills in 1962 was as follows (see also table 5, appendix):

	Mills	
	(Number)	(Percent of reported volume)
Mill size-class:[1]		
25 MMBF or more	59	59.0
15 to 24.9 MMBF	43	17.7
10 to 14.9 MMBF	47	13.2
5 to 9.9 MMBF	43	7.4
1 to 4.9 MMBF	49	2.5
Less than 1 MMBF	34	.2
Total, reporting mills	275	100.0
Nonreporting mills[2]	22	
Total	297	

[1]Rated by 1962 log receipts.

[2]Receipts by the individual nonreporting mills is unknown.

Sawlog Production, by Counties

Sawlogs were produced in 40 of California's 58 counties in 1962, but 69 percent of the cutting was concentrated in eight counties of northern California. The 10 leading counties are ranked below according to sawlog output. Humboldt County, as for many years, leads all others with 22.1 percent of the total sawlog production.

Rank and County:		Sawlog cut (MMBF)	Sawlog cut (Percent of reported volume)
1	Humboldt	1,022	22.1
2	Mendocino	546	11.8
3	Shasta	383	8.3
4	Siskiyou	372	8.1
5	Trinity	288	6.2
6	Plumas	205	4.4
7	Del Norte	197	4.3
8	El Dorado	183	4.0
9	Lassen	147	3.2
10	Tehama	144	3.1
	All others	1,132	24.5
	Total, reporting operators	4,619	100.0
	Estimate for nonreporting operators	133	
	Total, sawlog production	4,752	

Sawlog Receipts, by Counties

The eight counties having the greatest sawlog production were also those with the largest sawlog receipts. Their total sawlog receipts at mills amounted to 69 percent of California's total. Humboldt County logged 22.1 percent and received 22.8 percent of the total reported sawlog cut in California. Ranking of counties in 1962 was as follows (see also table 6, appendix):

Rank and County:		Sawlog receipts (MMBF)	Sawlog receipts (Percent of reported volume)
1	Humboldt	1,027	22.8
2	Mendocino	594	13.2
3	Siskiyou	401	8.9
4	Shasta	385	8.6
5	Plumas	239	5.3
6	Glenn-Tehama[1]	187	4.2
7	Trinity	168	3.7
8	Del Norte	147	3.3
9	El Dorado	137	3.0
10	Napa-Sonoma[1]	131	2.9
	All others	1,083	24.1
Total reporting mills		4,499	100.0
Estimate for non-reporting mills		123	
Total California mills[2]		4,622	
Exported sawlogs		130	
Total sawlog production		4,752	

[1]Combined to avoid disclosure of individual mills.
[2]Does not include imports.

For those counties playing a smaller part in the lumber industry of California, the variation between log harvest and mill receipts was more irregular. Some counties bordering the commercial forest zones exported their entire cut to counties having operating mills.

Sawlog Production from Dead Timber

Slightly more than 4 percent of the sawlogs produced came from dead timber; ponderosa and Jeffrey pine led all species (see also table 7, appendix):

Species:	Dead timber (MBF)	Dead timber (Percent)	Total sawlog production (Percent)
Douglas fir	33,350	16.4	0.7
Ponderosa & Jeffrey pine	76,846	37.7	1.7
Redwood	17,817	8.7	.4
True firs[1]	46,547	22.8	1.0
Sugar & western white pine	22,994	11.3	.5
Western hemlock	696	0.3	(2/)
Sitka spruce	0	0.0	0.0
Other softwoods	5,717	2.8	.1
Hardwoods	0	0.0	0.0
Total	203,967	100.0	4.4

[1]Includes white, red, and grand fir.
[2]Less than 0.1 percent.

Veneer Logs and Bolts

During 1962, 728 million board feet of peeler logs were harvested from California's forest lands. This was 13 percent of the total harvest of roundwood in California during that year. Most of this peeler log volume went to California plywood and veneer plants for manufacturing. Only 16 million board feet of peeler logs were shipped out of the State.

Peeler Log Production, by Species

Peeler log production was more than 36 percent higher in 1962 than in 1956. Douglas-fir was the predominant species cut for veneer logs in 1962, accounting for more than 87 percent of the 728 million board feet of total production. True firs were second with nearly 8 percent, and various other softwood and hardwood species made up the remaining 5 percent. Peeler log production, by species, in 1962 was as follows (see also table 8, appendix):

Species:	Peeler log production (MBF)	Peeler log production (Percent)
Douglas-fir	637,607	87.6
True firs[1]	56,203	7.7
Ponderosa and Jeffrey pine	19,524	2.7
Redwood	6,777	.9
Sugar pine	4,710	.7
Sitka spruce	1,260	.2
Western hemlock	520	.1
Other softwoods	1,060	.1
Hardwoods	191	(2/)
Total	727,852	100.0

[1]Includes white, red, and grand fir.
[2]Less than 0.1 percent.

Peeler Log Production, by Counties

Humboldt County led all California counties in the production of peeler logs, accounting for 49 percent of the total volume. Del Norte was second, with 14 percent; Siskiyou, third; and Mendocino, fourth. Twelve other counties produced the remainder:

County:	Peeler log production (MMBF)	Peeler log production (Percent)
Humboldt	357	49.0
Del Norte	102	14.0
Siskiyou	80	11.0
Mendocino-Sonoma-Santa Cruz[1]	64	8.8
All others	125	17.2
Total[2]	728	100.0

[1]Combined to avoid disclosure of individual plants.
[2]Includes exports.

Peeler Log Receipts, by Counties

The veneer and plywood industry in California is concentrated primarily in the counties adjoining the north coast: 28 of the 39 plants operating during 1962 were located along the coast between Del Norte and Santa Cruz counties. All remaining plants were situated from Calaveras northward to Siskiyou County.

About one-half of all peeler logs harvested in 1962 were delivered to plants in Humboldt County. Del Norte took in about 15 percent, and Siskiyou about 10 percent of the peeler log receipts. Counties ranked as follows (see also table 9, appendix):

	Active plants	Peeler log receipts	
	(No.)	(MMBF)	(Percent)
County:			
Humboldt	16	359	51
Del Norte	7	106	15
Siskiyou	4	69	10
Mendocino-Sonoma-Santa Cruz[1]	5	64	9
All others	7	114	15
Total	39	[2]712	100

[1]Combined to avoid disclosure of individual plants.

[2]Does not include imports or exports.

Plant Size-Class

The volume of logs received during 1962 was used as the basis for segregating plywood and veneer plants into size-classes. The 20 largest plants receiving 15 million board feet or more of logs accounted for 81 percent of the peeler volume delivered to California plants. On the other hand one-third of the plants received less than 10 million board feet each and could account for only 6 percent of the total volume. Number of plants in each plant-size was as follows (see also table 10, appendix):

	Active plants	Peeler log receipts	
	(No.)	(MMBF)	(Percent)
Plant-size class:			
25 MM bd. ft. or more	11	448.9	63
15 to 24.9 MM bd. ft.	9	132.3	18
10 to 14.9 MM bd. ft.	7	89.1	13
5 to 9.9 MM bd. ft.	3	25.4	4
1 to 4.9 MM bd. ft.	5	14.4	2
Less than 1 MM bd. ft.	4	1.9	(1/)
Total	39	[2]712.0	100

[1]Less than 0.5 percent.

[2]Does not include exports or imports.

Peeler Log Production from Dead Timber

Peeler logs were produced almost entirely from green timber in 1962. Dead timber accounted for only nine-tenths of 1 percent of the State's total peeler log cut. The peeler logs harvested from dead timber came entirely from three counties: Humboldt, Del Norte, and Trinity. More peeler logs were produced from dead Douglas-fir (97 percent) than from all other species of dead timber (see also table 11, appendix):

	Dead timber	
	(MBF)	(Percent)
Species:		
Douglas-fir	6,681	97.4
Ponderosa and Jeffrey pine	6	.1
True firs[1]	120	1.8
Sugar pine[2]	27	.4
Other softwoods	23	.3
[2]Total	6,857	100.0

[1]Includes white, red, and grand fir.
[2]Includes western white pine.

Pulp Logs and Wood Fiber Materials

Compared with the lumber, plywood, and veneer industry, the timber harvest for round pulpwood is very small--less than one-half of 1 percent of the total timber harvest. California had 11 plants that used raw wood as a fiber producing material during 1962 (table 12, appendix). These included two pulp mills, one hard board plant, four particle board plants, and four roofing felt and floor covering plants. The wood requirements of these plants were supplied almost entirely from residues obtained from sawmills, veneer and plywood plants, and remanufacturing plants.

The equivalent of 567.5 thousand units[2] of pulpwood, pulp chip, and other wood residues were delivered to California's fiber and board plants in 1962. This volume represented a 27 percent increase since 1956.[3]

Raw Materials Received

Pulp chips dominated the raw materials received at plants during 1962, accounting for nearly 85 percent of all deliveries; round pulpwood made up less than one-tenth of the total. The balance of receipts was in veneer cores, sawdust, wood shavings, and wood flour.

Species Received

The species composition of chips, mill ends, shavings, sawdust, and wood flour is usually an indeterminate mixture of several species. Because of its dark color, redwood is usually kept separate from the whitewood species. Softwood receipts predominated. In 1962 about 86 percent of the raw woody materials received at California plants were of softwood species. Eucalyptus made up 81 percent of the hardwood receipts, and cottonwood and miscellaneous hardwood the remainder.

---

[2]A unit 2,400 pounds bone-dry weight.

[3]May, R. H. Wood receipts by fiber and board plants in California, 1956. U.S. Forest Serv. Calif. Forest & Range Expt. Sta. Forest Survey Release 29, 3 pp. 1957.

Poles, Piling, and Mine Timbers

About 2, 818, 000 cubic feet of timber were harvested for poles, piling, and mine timbers in California in 1962. Most of this harvest came from young sawtimber because of its desirable size. This volume is equivalent to about 13, 192, 000 board feet (Internatl. 1/4-inch log rule) in this size of timber. Poles accounted for 74 percent of this volume, piling 16 percent, and round and hewn mine timbers for 10 percent.

Two-thirds of the total volume was Douglas-fir, nearly one-third was ponderosa pine, other conifers less than 1 percent, and eucalyptus slightly more than 1 percent.

Trinity County lead all others in volume of poles and piling produced with nearly 21 percent of the total. Mendocino and Shasta Counties tied with 18 percent each, and Nevada County produced 17 percent. These four counties accounted for 74 percent of the total reported production (table 13, appendix).

Production of round, hewn, and split mine timbers in 1962 was estimated to be 279, 000 cubic feet or the equivalent of about 1, 339, 000 board feet (Internatl. 1/4-inch log rule). Most of this volume was produced from conifer species. Production of mine timbers from hardwoods was reported only from southern California.

Pole and piling production in 1962 was less than 1956 production by 51 percent and 44 percent,respectively. On the other hand, mine timber production was estimated to be 64 percent higher than in 1956.

Split Products

About 3, 030, 000 cubic feet of timber, equivalent to about 24, 844, 000 board feet (Internatl. 1/4-inch log rule), were harvested as split products in 1962 (table 14, appendix). This is only slightly greater than the 1956 production. These hand-split commodities consist largely of fence posts and rails, grape stakes and cross-arms, bean poles, shakes, and fence paling and pickets.

Most split products--96 percent of California's production in 1962--are made from coast redwood because of its durability, ease of splitting, and availability in commercial timber stands. Incense-cedar provided 2 percent of the State's production in 1962, giant sequoia 1 percent, and the remaining 1 percent was made up of western red cedar, sugar pine, and miscellaneous softwoods. About 28 percent of the total production came from dead, windfallen, and salvage timber.

Ninety-three percent of the 1962 production came from five redwood region counties (table 15, appendix). Humboldt County led with 41 percent, Mendocino 24 percent, Del Norte 15 percent, Sonoma 9 percent, and Monterey 4 percent. The remaining 7 percent was produced in 15 other counties.

Three commodities made up 84 percent of total production. Grape stakes led with 43 percent, fence paling 23 percent, fence posts 18 percent. The remaining 16 percent was made up of nine other minor products.

Shingle and Sawed Shake Logs and Bolts

This category includes logs and bolts harvested for the manufacture of shingles and sawed shakes (split one side, sawed on the other). In 1962, the industry harvested 2,464,000 board feet of this material in California (table 16, appendix). When manufactured into products this volume of timber would yield about 25,870 squares of shingles and sawed shakes. This volume is enough to "roof" about 1,725 average size houses.

Humboldt County was the leading producer--accounting for 76 percent of the timber harvested for these products. Tulare was second with 11 percent. The remaining 13 percent was reported from five other counties: Del Norte and Mendocino on the coast and Fresno, Placer, and Tehama inland.

More coast redwood was cut than any other; it accounted for more than 80 percent of the total harvest. Giant sequoia, mostly from windfalls, made up 11 percent. Sugar pine, incense-cedar, and western redcedar made up the balance. More than half (52 percent) of the total harvest was reported to have come from dead timber. Total production from dead material probably was somewhat higher because the source of nearly 4 percent of total production was not reported.

Timber harvested for sawed shakes and shingles is on the decline. The 1962 cut was 36 percent below 1956 production. The number of active mills was down from 26 in 1956 to 15 in 1962, a 42-percent drop.

Fuelwood

Fuelwood consists of firewood and charcoal wood. It comes from two sources: roundwood and plant residues.

Some 20,414 cords of hardwoods were cut during 1962 for charcoal production (table 17, appendix). Of the known species that were cut, the oaks led all other species with 93 percent of the reported volume. The balance was composed largely of madrone and California laurel (pepperwood). Information on species was limited, no species data being reported for 58 percent of the total cut. More than 80 percent of the timber cut for coaling was in three coastal counties: Humboldt, San Benito and San Luis Obispo. The remaining production was centered on the west side of the central Sierra Nevada.

Firewood produced in the "round" was estimated at slightly more than 52,000 cords. The equivalent of an additional 2,183,000 cords of plant residues (largely from sawmills and peeler plants) were used both for domestic and industrial fuel and a small amount was processed into charcoal.

Roundposts

Industrial production of roundposts was almost negligible in 1962 (table 18, appendix). A total harvest of 10,000 cubic feet (equivalent to about 112,000 board feet in this size material) was reported. Approximately half of this was produced in Amador County. Most of the production was from softwood species. These data were obtained from concentration yards and preservative plants and public records. But no attempt was made to determine the volume of posts cut, largely from noncommercial species, on farms and ranches for their own use.

Appendix

Survey Procedure

A mailing list of all known active mills, plants, concentration yards, timber operators.and processors was compiled in cooperation with the California Division of Forestry, National Forest Supervisors, industry trade associations, U. S. Bureau of Mines, local port authorities, and county assessors.

Questionnaires were mailed to sawmills, and veneer and plywood plants; pulp, hard and particle board, and roofing felt plants; post, pole, and piling processors; shingle and shake mills, underground mines; split products operators and concentration yards; resident and nonresident (out-of-state) exporters of logs; and excelsior producers.

The questionnaires were designed to obtain information on the volume of roundwood harvested, giving breakdowns by individual mills and plants, and showing species received, by product type (sawlog, peeler log, shingle bolt, etc.), county of origin and county of receipt, live and dead material, and volume obtained from each of four ownership classes. Information was also requested on production, use or receipts of plant residues, by residue type, or both.

Second, and in some cases, third mail requests were sent to operators who failed to reply to earlier requests. Mail replies were received from four-fifths of the active timber operators. In industries with only a few operators, such as veneer-plywood; pulp, particle board and fiber, etc., all nonreplying operators were visited to get a 100-percent return. A random sample of nonreplying operators was selected for each industry for which complete coverage was not obtained (e.g., sawmills, nonresident log exporters, and split products) to provide a valid statistical estimate for this group. Sample operators were then visited by the enumerator to obtain the desired information.

Information on timber cut for posts, poles, piling, and split products was obtained largely from concentration yards, processing and preservative plants because of the large number of individual operators and the rapid changeover of people engaged in the industry. Timber volumes were reported in local use log rules and other units of measure and were converted to International 1/4-inch log rule and to cubic-foot equivalents as a common reporting base.

Listed below are the number of active operators in each industry in 1962, the number of replies received, the number of field contacts, and the number of operators whose receipts or production was estimated by sampling:

Industry:	Known active operators	Replies	Field contact	Receipts or production estimated by sampling
	(Number)			
Sawmills	297	253	22	22
Veneer & plywood	39	36	3	0
Post, pole & piling	21	21	0	0
Split products	161	119	12	30
Sawed shake & shingles	15	10	5	0
Pulp, particle & hard board & fiber	11	11	0	0
Log exporters:				
Resident	7	7	0	0
Non resident	23	9	5	9
Underground mines[1]	45	40	5	0
Total	619	506	52	61

[1]Mines of 1,000 tons of ore production and greater in 1962.

Statistical Accuracy

In varying degrees, all data in this report are subject to possible errors. Errors could have been introduced through mistakes in measuring, tabulating, and reporting, or through sampling procedures. Errors may or may not be compensating. Except for sampling errors there is no way of measuring them, but the chances of human error were reduced as far as possible by following detailed plans, by training of personnel, and by careful supervision and checking of the work.

All returned questionnaires were reviewed for reasonableness, consistency, and completeness. Those reports that needed verification or completion were clarified by further contact with the originators. In this manner it is believed that reporting errors were minimized. Tabulating and computational errors were held to a minimum by use of electronic data processing machines and programed cross-checks.

Sampling error accounts for errors that arise from taking a sample rather than making a complete inventory or measurement; it does not include possible errors due to human or machine mistakes or incomplete lists. The sampling error of an estimate is given here in terms of one standard error, i. e., the range about the estimate within which the odds are two to one that the value based on 100-percent coverage would fall.

The nationwide Forest Survey has set the maximum acceptable sampling error for timber harvested from growing stock at 15 percent per billion cubic feet. The survey reported in this paper bettered the national maximum by a wide margin. The sampling error for sawlog production was calculated to be ±2.4 percent; for the split products harvest it was ±2.8 percent. For the total timber harvest (excluding round fuelwood) the sampling error was ±2.1 percent. This is equivalent to a sampling error of ±1.85 percent per billion cubic feet for the total timber harvest of 793,414,000 cubic feet (excluding fuelwood). Data on timber harvested for the following products included no sampling errors because the output for all known operations was obtained by canvass: peeler logs; pulp and fiber; sawed shake logs and shingles; posts, poles, and piling; and mine timbers. Sampling error for round fuelwood, cut mostly from noncommercial forest land and from nongrowing stock, was not calculable as estimated total production (less than 1 percent of the total harvest) was compiled from a variety of uncontrolled sources and records. This omission is considered negligible.

Table 1.--*Timber harvest in California, by commodity and species, 1962*[1]

Commodity	Total volume		Douglas-fir	Ponderosa pine[2]	Redwood[3]	True firs[4]	Sugar pine[5]	Western hemlock	Sitka spruce	Other softwoods	Oaks	Other hardwoods	Undistributed[6]
	MBF[7]	*Percent*	*MBF*[7]										
Sawlogs	4,751,900	85.3	1,488,005	857,858	906,536	798,456	394,241	3,921	4,949	160,983	3,642	--	133,309
Veneer logs, bolts	727,852	13.1	637,607	19,524	6,777	56,203	4,710	520	1,260	1,060	5	186	--
Pulpwood	22,452	.4	429	--	--	2,309	--	--	--	--	--	19,714	--
Poles	9,650	.2	6,868	2,695	--	87	--	--	--	--	--	--	--
Piling	2,203	(8/)	1,107	936	--	--	--	--	--	--	--	160	--
Mine timbers	1,339	(8/)	--	--	--	--	--	--	--	--	--	--	1,339
Split products	24,844	.4	--	--	23,354	--	27	--	--	682	--	--	781
Shingles, sawed shakes	2,464	.1	--	--	2,256	--	70	--	--	138	--	--	--
Fuelwood	27,123	.5	--	--	--	--	--	--	--	--	2,157	167	24,799
Round posts	112	(8/)	--	3	5	22	--	--	--	25	1	--	56
All commodities	5,569,939		2,134,016	881,016	938,928	857,077	399,048	4,441	6,209	162,888	5,805	20,227	160,284
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
		100.0	38.3	15.8	16.8	15.4	7.2	0.1	0.1	2.9	0.1	0.4	2.9

[1]Includes both live and dead timber from both commercial and noncommercial forest land.
[2]Includes Jeffrey pine.
[3]Includes 271 MBF of giant sequoia.
[4]Includes white, red, and grand fir.
[5]Includes western white pine.
[6]Includes estimates for nonreporting operators plus reported volume for which species information was unknown.
[7]International 1/4-inch log rule.
[8]Less than 0.1 percent.

Table 2.--*Timber harvest in California, by county of origin and commodity, 1962*[1]

(Thousand board feet, International 1/4-inch log rule)

County	Total volume	Sawlogs	Veneer logs and bolts	Split products[2]	Miscellaneous[3]
Alameda	157	--	--	--	157
Alpine	416	416	--	--	--
Amador	34,825	32,891	(4/)	(4/)	1,934
Butte	37,168	36,866	(4/)	(4/)	302
Calaveras	72,899	71,698	(4/)	--	1,201
Colusa	87	--	--	--	87
Contra Costa	228	--	--	--	228
Del Norte	301,966	196,638	101,536	3,736	56
El Dorado	184,017	182,844	(4/)	--	1,173
Fresno	115,806	115,185	--	76	545
Glenn	29,995	29,929	--	--	66
Humboldt	1,396,366	1,022,129	357,478	12,044	4,715
Kern	3,317	3,124	--	--	193
Kings	44	--	--	--	44
Lake	33,150	32,397	--	--	753
Lassen	147,560	147,163	--	(4/)	397
Los Angeles	147	--	--	--	147
Madera	79,407	79,272	--	11	124
Marin	99	--	--	--	99
Mariposa	2,903	1,937	--	--	966
Mendocino	604,671	546,199	49,037	6,002	3,433
Merced	5,623	5,564	--	--	59
Modoc	33,360	33,238	(4/)	(4/)	122
Mono	11,856	11,856	--	--	--
Monterey	8,298	227	--	983	7,088
Napa	18,658	18,150	--	--	508
Nevada	75,207	72,722	--	(4/)	2,485
Orange	57	--	--	--	57
Placer	133,064	131,646	(4/)	143	1,275
Plumas	205,882	204,579	--	228	1,075
Riverside	5,291	5,215	--	--	76
Sacramento	108	--	--	--	108
San Benito	108	--	--	--	108
San Bernardino	12,168	12,041	--	--	127
San Diego	503	53	--	--	450
San Joaquin	175	--	--	--	175
San Luis Obispo	6,349	32	--	--	6,317
San Mateo	25,622	25,572	--	--	50
Santa Barbara	203	--	--	--	203
Santa Clara	310	156	--	--	154
Santa Cruz	28,415	26,836	(4/)	120	1,459
Shasta	385,951	382,822	(4/)	(4/)	3,129
Sierra	75,024	74,948	--	(4/)	76
Siskiyou	372,925	372,209	(4/)	(4/)	716
Solano	41	--	--	--	41
Sonoma	138,763	127,123	(4/)	2,359	9,281
Stanislaus	152	--	--	--	152
Sutter	52	--	--	--	52
Tehama	145,908	144,719	(4/)	118	1,071
Trinity	291,119	288,240	(4/)	--	2,879
Tulare	62,028	60,465	--	550	1,013
Tuolumne	35,621	34,274	--	(4/)	1,347
Ventura	4,752	4,191	--	--	561
Yolo	454	--	--	--	454
Yuba	69,735	69,632	--	(4/)	103
Undistributed[5]	370,929	146,702	219,801	1,050	3,376
Total	5,569,939	4,751,900	727,852	27,420	62,767

[1]Includes both live and dead timber from both commercial and noncommercial forest land.

[2]Includes split products, shingle and shake logs and bolts and posts.

[3]Includes round pulpwood, poles, piling, mine timbers and fuelwood.

[4]Combined with "Undistributed" to avoid disclosure of individual producers.

[5]Includes estimates for nonreporting operators plus reported volume for which county of origin was unknown and volumes combined to avoid disclosure of individual operators.

County	Total volume		Douglas-fir	Ponderosa pine[2]	Redwood	True firs[3]	Sugar pine[4]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	MBF[5]	Percent	MBF[5]								
Alpine	416	(6/)	--	260	--	156	--	--	--	--	--
Amador	32,891	0.7	3,685	20,028	--	3,776	2,393	--	--	3,009	--
Butte	36,866	.8	5,667	17,191	--	7,923	4,644	--	--	1,441	--
Calaveras	71,698	1.5	2,201	21,296	--	21,323	13,460	--	--	13,418	--
Del Norte	196,638	4.1	81,890	66	102,578	976	4,575	1,498	1,919	3,136	--
El Dorado	182,844	3.8	19,744	57,653	--	59,583	23,482	--	--	22,382	--
Fresno	115,185	2.4	762	52,692	--	39,005	17,932	--	--	4,794	--
Glenn	29,929	.6	8,401	10,093	--	7,809	3,316	--	--	310	--
Humboldt	1,022,129	21.5	539,310	4,104	435,887	25,190	13,836	475	3,030	297	--
Kern	3,124	.1	--	3,124	--	--	--	--	--	--	--
Lake	32,397	.7	12,392	10,883	--	548	8,506	--	--	68	--
Lassen	147,163	3.1	7,772	69,029	--	59,478	8,851	--	--	2,033	--
Madera	79,272	1.7	--	24,686	--	39,691	12,102	--	--	2,793	--
Mariposa	1,937	(6/)	--	1,926	--	--	11	--	--	--	--
Mendocino	546,199	11.5	222,926	19,099	292,091	6,477	5,330	--	--	276	--
Merced	5,564	.1	156	5,200	--	208	--	--	--	--	--
Modoc	33,238	.7	--	17,280	--	12,896	--	--	--	3,062	--
Mono	11,856	.2	--	9,776	--	2,080	--	--	--	--	--
Monterey	227	(6/)	--	--	--	--	--	--	--	227	--
Napa	18,150	.4	2,692	5,736	--	8,380	--	--	--	1,342	--
Nevada	72,722	1.5	11,458	29,533	--	24,215	3,276	--	--	4,240	--
Placer	131,646	2.8	19,229	31 305	--	59,910	14,332	--	--	6,870	--
Plumas	204,579	4.3	29,066	44,126	--	91,389	24,231	--	--	15,767	--
Riverside	5,215	.1	--	3,653	--	1,040	521	--	--	1	--
San Bernardino	12,041	.3	--	9 961	--	1,560	520	--	--	--	--
San Diego	53	(6/)	--	26	--	18	--	--	--	9	--
San Luis Obispo	32	(6/)	--	--	--	--	--	--	--	32	--
San Mateo	25,572	.5	5,320	--	20,252	--	--	--	--	--	--
Santa Clara	156	(6/)	--	--	156	--	--	--	--	--	--
Santa Cruz	26,836	.6	6,908	--	19,928	--	--	--	--	--	--
Shasta	382,822	8.1	84,552	111,145	--	89,031	55,060	--	--	40,432	2,602
Sierra	74,948	1.6	1,887	11,256	--	19,241	40,335	778	--	1,451	--
Siskiyou	372,209	7.8	130,608	95,577	--	92,549	33,393	--	--	19,042	1,040
Sonoma	127,123	2.7	84,630	312	35,529	5,012	1,640	--	--	--	--
Tehama	144,719	3.0	24,932	42,964	--	33,607	39,364	--	--	3,852	--
Trinity	288,240	6.1	152,142	64,217	--	29,981	36,380	9	--	5,511	--
Tulare	60,465	1.3	--	25,509	115	23,304	9,239	--	--	2,298	--
Tuolumne	34,274	.7	851	17,555	--	10,677	4,622	--	--	569	--
Ventura	4,191	.1	--	3,151	--	1,040	--	--	--	--	--
Yuba	69,632	1.5	18,412	16,550	--	20,212	10,986	1,161	--	2,311	--
Unknown[7]	13,393	.3	10,412	896	--	171	1,904	--	--	10	--
Undistributed[8]	133,309	2.8	--	--	--	--	--	--	--	--	--
All counties[9]	4,751,900		1,488,005	857,858	906,536	798,456	394,241	3,921	4,949	160,983	3,642
		Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
		100.0	31.3	18.1	19.1	16.8	8.3	0.1	0.1	3.4	0.1

[1]Includes both live and dead timber.

[2]Includes Jeffrey pine.

[3]Includes white, red, and grand fir.

[4]Includes western white pine.

[5]International 1-1/4-inch log rule.

[6]Less than 0.1 percent of total volume.

[7]County of origin was unknown by some reporting operators.

[8]Estimated for nonreporting operators.

[9]Species figures do not include 133,309 M feet of ''undistributed'' volume.

Table 4.--*Sawlog exports in California, by species, 1962*

Species	21 active exporters reporting	9 active exporters not reporting
	MBF[1]	
Softwoods:		
Douglas-fir	57,423	--
Ponderosa pine[2]	14,507	--
Redwood	1,582	--
True fir[3]	30,790	--
Sugar pine[4]	9,422	--
Western hemlock	351	--
Sitka spruce	--	--
Other softwoods	5,984	--
Hardwoods	--	--
Total	120,059	[5]10,117

[1]International 1/4-inch log rule.

[2]Includes Jeffrey pine.

[3]Includes white, red, and grand fir.

[4]Includes western white pine.

[5]Estimated for active exporters not reporting.

Table 5.--*Sawlog receipts in California, by mill size-class and species, 1962*

Mill size-class (based on 1962 receipts)[1]	Active sawmills	Total volume		Douglas-fir	Ponderosa pine[2]	Redwood	True firs[3]	Sugar pine[4]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	Number	*MBF*[1]	*Percent reported*	*MBF*[1]								
50 MM and over	10	863,821	19.2	165,277	183,892	219,526	155,345	112,886	--	--	26,895	--
25.0-49.9 MM	49	1,790,612	39.8	573,779	327,477	358,505	306,829	181,574	3,085	1,265	38,096	2
15.0-24.9 MM	43	797,969	17.7	329,282	138,455	114,621	127,916	53,175	73	1,413	33,034	--
10.0-14.9 MM	47	596,321	13.2	196,603	117,274	127,133	93,551	25,768	37	452	35,503	--
5.0- 9.9 MM	43	331,164	7.4	116,827	57,673	57,607	68,803	8,434	251	1,803	19,766	--
1.0- 4.9 MM	49	111,314	2.5	44,043	17,618	26,596	15,090	2,815	125	16	1,371	3,640
500-999 M	5	3,876	.1	3,089	417	216	--	154	--	--	--	--
50-499 M	16	3,225	.1	1,681	432	728	113	11	--	--	260	--
1- 49 M	13	230	(5/)	--	116	21	18	1	--	--	74	--
Total reported	275	4,498,532	100.0	1,430,581	843,354	904,953	767,665	384,818	3,571	4,949	154,999	3,642
Undistributed[6]	22	123,292		--	--	--	--	--	--	--	--	--
All size-classes	297	4,621,824		--	--	--	--	--	--	--	--	--
				Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Percent reported				31.8	18.8	20.1	17.0	8,6	0.1	0.1	3.4	0.1

[1]MM = million board feet; M = thousand board feet, both International 1/4-inch log rule.

[2]Includes Jeffrey pine.

[3]Includes white, red, and grand fir.

[4]Includes western white pine.

[5]Less than 0.1 percent.

[6]Estimated for active nonreporting sawmills.

Table 6.--*Sawlog receipts at sawmills in California, by species and county, 1962*

County	Active sawmills	Total volume		Douglas-fir	Ponderosa pine[1]	Redwood	True firs[2]	Sugar pine[3]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	No.	*MBF*[4]	*Percent reported*	*MBF*[4]								
Amador-Calaveras[5]	4	119,701	2.7	9,982	38,064	--	28,733	18,438	--	--	24,484	--
Butte	6	70,657	1.6	15,929	16,731	--	25,622	10,088	--	--	2,287	--
Del Norte	11	147,373	3.3	43,128	--	100,088	976	104	1,148	1,919	10	--
El Dorado	7	137,268	3.1	13,032	47,546	--	45,856	18,964	--	--	11,870	--
Fresno	7	53,607	1.2	762	10,053	--	31,773	7,960	--	--	3,059	--
Glenn-Tehama[5]	3	186,635	4.1	45,183	68,152	--	35,902	33,708	--	--	3,690	--
Humboldt	52	1,027,075	22.8	561,757	7,488	414,963	22,999	16,038	484	3,030	316	--
Inyo-Kern[5]	3	11,891	.3	--	9,811	--	2,080	--	--	--	--	--
Lassen	5	99,565	2.2	2,023	43,719	--	51,015	1,691	--	--	1,117	--
Madera	5	79,109	1.8	--	24,967	--	39,669	11,707	--	--	2,766	--
Mariposa-Merced[5]	4	16,541	.4	156	14,086	--	208	2,091	--	--	--	--
Mendocino	39	594,489	13.2	227,715	33,926	312,389	7,004	13,112	--	--	343	--
Modoc	6	60,672	1.3	3,209	31,369	--	21,723	--	--	--	4,371	--
Monterey-San Luis Obispo-Santa Cruz[5]	10	45,594	1.0	9,887	--	35,448	--	--	--	--	259	--
Napa-Sonoma[5]	15	131,400	2.9	84,385	312	37,063	8,132	1,508	--	--	--	--
Nevada	8	79,550	1.8	17,319	27,113	--	28,927	1,979	--	--	4,212	--
Placer	7	91,525	2.0	13,387	25,954	--	38,263	9,496	--	--	4,425	--
Plumas	10	239,004	5.3	29,433	47,269	--	102,720	43,799	--	--	15,783	--
Riverside-San Bernardino[5]	4	24,536	.5	--	19,854	--	3,640	1,041	--	--	1	--
Sacramento-San Joaquin-Tuolumne[5]	8	68,893	1.5	1,468	27,577	--	22,417	7,493	--	--	9,938	--
San Diego	3	53	(6/)	--	26	--	18	--	--	--	9	--
San Mateo-Santa Clara[5]	3	7,228	.2	2,340	--	4,888	--	--	--	--	--	--
Shasta	13	385,290	8.6	85,795	111,957	--	91,146	56,507	--	--	36,243	3,642
Siskiyou	16	400,631	8.9	141,563	114,997	--	84,536	41,605	--	--	17,930	--
Sierra	3	51,853	1.2	--	5,448	--	7,331	37,825	778	--	471	--
Trinity	13	167,991	3.7	102,271	31,092	--	12,716	18,619	--	--	3,293	--
Tulare	4	112,926	2.5	--	60,677	114	30,558	17,516	--	--	4,061	--
Yuba	6	87,475	1.9	19,857	25,166	--	23,701	13,529	1,161	--	4,061	--
Total reported	275	4,498,532	100.0	1,430,581	843,354	904,953	767,665	384,818	3,571	4,949	154,999	3,642
Undistributed[7]	22	123,292	--	--	--	--	--	--	--	--	--	--
Total, all counties	297	4,621,824	--	--	--	--	--	--	--	--	--	--
Percent reported				*Percent* 31.8	*Percent* 18.7	*Percent* 20.1	*Percent* 17.1	*Percent* 8.6	*Percent* 0.1	*Percent* 0.1	*Percent* 3.4	*Percent* 0.1

[1]Includes Jeffrey pine.
[2]Includes white, red, and grand fir.
[3]Includes western white pine.
[4]International 1/4-inch log rule.
[5]Combined to avoid disclosure of individual sawmills.
[6]Less than 0.1 percent.
[7]Estimated for active nonreporting sawmills.

Table 7.--*Production of sawlogs from live and dead timber in California, by species, 1962*

Species	Total volume		Live timber volume		Dead timber volume	
	MBF[1]	*Percent reported*[2]	*MBF*[1]	*Percent reported*[3]	*MBF*[1]	*Percent reported*[4]
Douglas-fir	1,488,005	32.2	1,454,655	33.0	33,350	16.4
Ponderosa pine[5]	857,858	18.6	781,012	17.7	76,846	37.7
Redwood	906,536	19.6	888,719	20.1	17,817	8.7
True fir[6]	798,456	17.3	751,909	17.0	46,547	22.8
Sugar pine[7]	394,241	8.5	371,247	8.4	22,994	11.3
Western hemlock	3,921	.1	3,225	.1	696	.3
Spruce, sitka	4,949	.1	4,949	.1	--	--
Other softwoods	160,983	3.5	155,266	3.5	5,717	2.8
Oaks[8]	3,642	.1	3,642	.1	--	--
Total reported	4,618,591	100.0	4,414,624	100.0	203,967	100.0
Undistributed[9]	133,309	--	--	--	--	--
All species	4,751,900	--	--	--	--	--

[1]International 1/4-inch log rule.
[2]Based on total volume.
[3]Based on live volume only.
[4]Based on dead volume only.
[5]Includes Jeffrey pine.
[6]Includes white, red, and grand fir.
[7]Includes western white pine.
[8]No other hardwoods reported.
[9]Estimated for nonreporting operators.

Table 8.--*Peeler log production in California, by county of origin and species, 1962*

County	Total volume		Douglas-fir	Ponderosa pine[1]	Redwood	True firs[2]	Sugar pine[3]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	MBF[4]	*Percent*	*MBF*[4]								
Amador-Butte-Calaveras-El Dorado-Placer-Modoc[5]	51,734	7.1	11,218	2,118	--	38,398	--	--	--	--	--
Del Norte	101,536	14.0	96,095	1,179	1,575	114	--	520	1,248	780	25
Humboldt	357,478	49.1	350,434	--	5,202	1,664	--	--	12	--	166
Mendocino	49,037	6.7	49,037	--	--	--	--	--	--	--	--
Santa Cruz-Sonoma[5]	14,901	2.1	14,621	--	--	--	--	--	--	280	--
Shasta-Tehama-Trinity[5]	73,607	10.1	53,467	8,869	--	9,907	1,364	--	--	--	--
Siskiyou	79,559	10.9	62,735	7,358	--	6,120	3,346	--	--	--	--
All counties	727,852	100.0	637,607	19,524	6,777	56,203	4,710	520	1,260	1,060	191
			Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
			87.6	2.7	0.9	7.7	0.6	0.1	0.2	0.2	(6)

[1] Includes Jeffrey pine.
[2] Includes white, red, and grand fir.
[3] Includes western white pine.
[4] International 1/4-inch log rule.
[5] Combined to avoid disclosure of individual operators.
[6] Less than 0.1 percent.

Table 9.--*Peeler log receipts at plants in California, by species and county, 1962*[1]

County	Active plants	Total volume		Douglas-fir	Ponderosa pine[2]	Redwood	True firs[3]	Sugar pine[4]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	No.	*MBF*[5]	*Percent*	*MBF*[5]								
Amador-Butte-Calaveras-El Dorado[6]	4	50,754	7.1	11,218	3,297	--	36,239	--	--	--	--	--
Del Norte	7	105,897	14.9	103,784	--	40	114	--	520	1,248	--	191
Humboldt	16	359,262	50.5	347,812	--	6,737	4,701	--	--	12	--	--
Mendocino-Sonoma-Santa Cruz[6]	5	63,938	9.0	63,658	--	--	--	--	--	--	280	--
Shasta-Tehama-Trinity[6]	3	63,553	8.9	46,013	8,349	--	8,243	948	--	--	--	--
Siskiyou	4	68,618	9.6	54,898	7,878	--	2,080	3,762	--	--	--	--
All counties	39	712,022	100.0	627,383	19,524	6,777	51,377	4,710	520	1,260	280	191
				Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
				88.1	2.7	1.0	7.2	.7	.1	.2	(7/)	(7/)

[1] Does not include 15,830 MBF exported from the State.
[2] Includes Jeffrey pine.
[3] Includes white, red, and grand fir.
[4] Includes western white pine.
[5] International 1/4-inch log rule.
[6] Combined to avoid disclosure of individual plants.
[7] Less than 0.1 percent.

Table 10.--*Peeler log receipts in California, by plant size-class and species, 1962*[1]

Plant size-class[2] (basis: 1962 receipts)	Active plants	Total volume		Douglas-fir	Ponderosa pine[3]	Redwood	True firs[4]	Sugar pine[5]	Western hemlock	Sitka spruce	Other softwoods	Hardwoods
	No.	*MBF*[2]	*Percent*	*MBF*[2]								
25 MM and over	13	448,949	63.0	395,520	8,947	2,028	38,564	3,670	--	220	--	--
15 MM - 24.9 MM	7	132,290	18.6	117,181	7,280	4,709	2,080	1,040	--	--	--	--
10 MM - 14.9 MM	7	89,149	12.5	81,926	--	--	5,663	--	520	1,040	--	--
5 MM - 9.9 MM	3	25,376	3.6	22,048	--	--	3,328	--	--	--	--	--
1 MM - 4.9 MM	5	14,365	2.0	9,440	3,297	--	1,628	--	--	--	--	--
Less than 1 MM	4	1,893	.3	1,268	--	40	114	--	--	--	280	191
All plants	39	712,022	100.0	627,383	19,524	6,777	51,377	4,710	520	1,260	280	191
				Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
				88.1	2.7	1.0	7.2	.7	.1	.2	(6/)	(6/)

[1]Does not include 15,830 MBF exported from the State.
[2]MM = million board feet; M = thousand board feet, International 1/4-inch log rule.
[3]Includes Jeffrey pine.
[4]Includes white, red, and grand fir.
[5]Includes western white pine.
[6]Less than 0.1 percent.

Table 11.--*Peeler log production from live and dead timber in California, by species, 1962*

Species	Total volume		Live timber volume		Dead timber volume	
	MBF[1]	*Percent*[2]	*MBF*[1]	*Percent*[3]	*MBF*[1]	*Percent*[4]
Softwoods:						
Douglas-fir	637,607	87.6	630,926	87.5	6,681	97.4
Ponderosa pine[5]	19,524	2.7	19,518	2.7	6	.1
Redwood	6,777	.9	6,777	.9	--	--
True firs[6]	56,203	7.7	56,083	7.8	120	1.8
Sugar pine[7]	4,710	.7	4,683	.6	27	.4
Western hemlock	520	.1	520	.1	--	--
Sitka spruce	1,260	.2	1,260	.2	--	--
Other softwoods	1,060	.1	1,037	.2	23	.3
Total softwoods	727,661	100.0	720,804	100.0	6,857	100.0
Hardwoods	191	([8])	191	([8])	--	--
All species	727,852		720,995		6,857	
	Percent		*Percent*		*Percent*	
	100.0		99.1		.9	

[1]International 1/4-inch log rule.
[2]Based on total volume.
[3]Based on live volume only.
[4]Based on dead volume only.
[5]Includes Jeffrey pine.
[6]Includes white, red, and grand fir.
[7]Includes western white pine.
[8]Less than 0.1 percent of total volume, all species.

Table 12.--*Fiber and board plant receipts in California, by species group, 1962*

Commodity and species groups	Plants	Total volume		Volume received		
				Chips	Pulpwood	Miscellaneous[1]
	Number	*Bone-dry unit*[2]	*Percent*	*Bone-dry unit*[2]	*Bone-dry unit*[2]	*Bone-dry unit*[2]
Fiber materials:	4					
Softwoods		10,361	1.8	5,944	--	4,417
Hardwoods		--	--	--	--	--
Unknown[3]		16,850	3.0	8,900	--	7,950
Total		27,211	4.8	14,844	--	12,367
Particleboard:	4					
Softwoods		63,976	11.3	41,450	--	22,526
Hardwoods		--	--	--	--	--
Unknown[3]		95,598	16.8	95,598	--	--
Total		159,574	28.1	137,048	--	22,526
Hardwood, pulp and paper[4]:	3					
Softwoods		313,476	55.2	307,864	5,612	--
Hardwoods		50,162	8.9	--	50,162	--
Unknown[3]		17,115	3.0	17,115	--	--
Total		380,753	67.1	324,979	55,774	--
All products:	11					
Softwoods		387,813	68.3	355,258	5,612	26,943
Hardwoods		50,162	8.9	--	50,162	--
Unknown[3]		129,563	22.8	121,613	--	7,950
Total, all species		567,538		476,871	55,774	34,893
		Percent		*Percent*	*Percent*	*Percent*
		100.0		84.0	9.8	6.2

[1]Includes veneer cores, plant residues (slabs, trimmings, shavings, sawdust), and wood flour.

[2]A bone-dry unit = 2,400 pounds, oven-dry chips of all species; about one standard cord.

[3]Chips, trimmings, shavings, sawdust, and wood flour frequently are an unsegregated mixture of several species.

[4]Combined to avoid disclosure of individual plants. Excludes mills operating on purchased pulp or on pulp imported from outside the State.

Table 13.--*Production of poles and piling in California, by county and species, 1962*

County	Total volume			Douglas-fir	Ponderosa pine[1]	True firs[2]	Eucalyptus
	M cu. ft.	*MBF*[3]	*Percent*	*MBF*[3]			
El Dorado	69	318	2.7	226	92	--	--
Humboldt	84	388	3.3	388	--	--	--
Lake	9	45	.4	45	--	--	--
Lassen	67	310	2.6	--	310	--	--
Mariposa	99	462	3.9	67	308	87	--
Mendocino	451	2,135	18.0	2,135	--	--	--
Monterey	35	160	1.3	--	--	--	160
Nevada	426	2,048	17.3	898	1,150	--	--
Placer	85	393	3.3	301	92	--	--
Plumas	190	875	7.4	608	267	--	--
Shasta	463	2,132	18.0	1,248	884	--	--
Sonoma	23	112	.9	112	--	--	--
Trinity	538	2,475	20.9	1,947	528	--	--
All counties	2,539	11,853[4]	100.0	7,975	3,631	87	160
				Percent	*Percent*	*Percent*	*Percent*
				67.3	30.6	0.7	1.4

[1]Includes Jeffrey pine.

[2]Includes white and red fir.

[3]International 1/4-inch log rule.

[4]Includes 84,305 poles and 766,000 linear feet of piling.

Table 14.--*Production of logs and bolts for split products in California, by county and commodity, 1962*

County	Total volume		Split fence posts	Split fence rails	Grape stakes	Bean poles	Split shakes	Paling	Pickets	Misc. split products[1]
	MBF[2]	*Percent reported*	*MBF*[2]							
Butte-Yuba[3]	62	0.3	22	--	40	--	--	--	--	--
Del Norte	3,646	15.2	164	55	2,687	--	--	740	--	--
Fresno	34	.1	11	1	--	--	--	--	--	22
Humboldt	10,167	42.3	1,639	601	3,591	8	377	3,805	137	9
Lassen-Modoc[3]	33	.1	32	--	--	--	1	--	--	--
Madera-Tuolumne[3]	29	.1	8	--	--	--	21	--	--	--
Mendocino	5,905	24.5	1,198	256	3,319	106	596	254	3	4/ 173
Monterey	983	4.1	176	46	82	--	16	598	--	65
Placer	26	.1	25	--	--	--	1	--	--	--
Plumas	228	.9	211	10	7	--	--	--	--	--
Santa Cruz	119	.5	53	--	41	--	5	--	5	15
Shasta-Tehama[3]	149	.6	148	--	--	--	1	--	--	--
Sierra-Nevada[3]	42	.2	30	5	--	--	6	--	1	--
Sonoma	2,359	9.8	636	18	510	85	1,053	57	(5/)	--
Tulare	281	1.2	47	2	--	--	17	--	--	6/ 215
Total reported	24,063	100.0	4,400	994	10,277	199	2,094	5,454	146	499
Undistributed[7]	781		--	--	--	--	--	--	--	--
All counties	24,844		--	--	--	--	--	--	--	--
Percent reported			*Percent* 18.3	*Percent* 4.1	*Percent* 42.7	*Percent* 0.8	*Percent* 8.7	*Percent* 22.7	*Percent* 0.6	*Percent* 2.1

[1]Miscellaneous split products include patio blocks, ties, hewn redwood cants, slabs and cross-arms.

[2]International 1/4-inch log rule.

[3]Combined to avoid disclosure of individual operators.

[4]Includes 45 MBF of ''hollywood boards.''

[5]Less than 500 board feet.

[6]Includes 177 MBF of ''hollywood boards.''

[7]Estimated for nonreporting producers.

Table 15.--*Production of logs and bolts for split products in California, by county of origin and species, 1962*

County of origin[1]	Total volume		Cedar[2]	Redwood[3]	Sugar pine	Other softwoods
	MBF[4]	*Percent reported*	*MBF*[4]			
Butte-Yuba[5]	62	0.3	22	--	--	40
Del Norte	3,646	15.2	--	3,646	--	--
Fresno	34	.1	12	22	--	--
Humboldt	10,167	42.3	76	10,091	--	--
Lassen-Modoc[5]	33	.1	20	--	1	12
Madera-Tuolumne[5]	29	.1	11	--	18	--
Mendocino	5,905	24.5	--	5,905	--	--
Monterey	983	4.1	--	983	--	--
Placer	26	.1	26	--	--	--
Plumas	228	.9	228	--	--	--
Santa Cruz	119	.5	--	119	--	--
Shasta-Tehama[5]	149	.6	148	--	1	--
Sierra-Nevada[5]	42	.2	35	--	7	--
Sonoma	2,359	9.8	--	2,359	--	--
Tulare	281	1.2	51	230	--	--
Total reported	24,063	100.0	2/629	3/23,355	27	52
Undistributed[6]	781	--	--	--	--	--
All counties	24,844	--	--	--	--	--
Percent reported			*Percent* 2.6	*Percent* 97.1	*Percent* 0.1	*Percent* 0.2

[1]County of origin is generally the same as county of receipt for split products. Only four operators reported receipts from across county lines.

[2]Includes 553 MBF of incense-cedar and 76 MBF of western red cedar.

[3]Includes 252 MBF of giant sequoia.

[4]International 1/4-inch log rule.

[5]Combined to avoid disclosure of individual operators.

[6]Estimated for nonreporting producers.

Table 16.--*Production of logs and bolts for shingles and sawed shakes in California, by county, live and dead timber, and species, 1962*

County of harvest and type of timber	Active mills	Total volume		Redwood[1]	Sugar pine	Cedar[2]
	Number	*Percent*	*MBF*[3]			
Del Norte-Mendocino[4]	4					
Live timber		0.6	16	16	--	--
Dead timber		5.4	132	57	--	75
Unknown[5]		1.5	36	36	--	--
Total		7.5	184	109	--	75
Humboldt:	3					
Live timber		37.7	930	930	--	--
Dead timber		37.7	930	930	--	--
Unknown[5]		.6	16	16	--	--
Total		76.0	1,876	1,876	--	--
Fresno-Placer-Tehama[4]	4					
Live timber		2.8	70	--	29	41
Dead timber		2.6	63	--	41	22
Unknown[5]		--	--	--	--	--
Total		5.4	133	--	70	63
Tulare:	4					
Live timber		3.1	76	76	--	--
Dead timber		6.2	153	153	--	--
Unknown[5]		1.7	42	42	--	--
Total		11.0	271	271	--	--
All counties:	15					
Live timber		44.3	1,092	1,022	29	41
Dead timber		51.9	1,278	1,140	41	97
Unknown[5]		3.8	94	94	--	--
Total, all species			2,464	[1/]2,256	70	138
			Percent	*Percent*	*Percent*	*Percent*
			100.0	91.5	2.9	5.6

[1]Includes 271 MBF of giant sequoia produced in Tulare County.

[2]Western redcedar in Del Norte County; incense-cedar in all other counties.

[3]International 1/4-inch log rule.

[4]Combined to avoid disclosure of individual operators.

[5]Information on live and dead timber not reported by some operators.

Table 17.--*Fuelwood production in California, by region of origin and species, 1962*[1]

Commodity	Total volume			Oaks	Madrone and pepperwood	Undistributed hardwoods[2]
	MBF	*Cords*	*Percent*	*Cords*		
Fuelwood	21,550	52,054	--	--	--	--
Charcoal:						
Coast region[3]	4,540	16,632	81.5	4,280	612	11,740
Pine region[4]	1,033	3,782	18.5	3,622	--	160
Total, all regions	5,573	20,414	100.0	7,902	612	11,900
			Percent	*Percent*	*Percent*	*Percent*
			100.0	38.7	3.0	58.3
Total, all commodities	27,123	72,468	--	--	--	--

[1]Production from roundwood only. An additional 2,183,000 cords of plant residues were used for fuel and charcoal production.

[2]Includes all material for which species was not reported.

[3]Includes Humboldt, San Benito, and San Luis Obispo counties.

[4]Includes Tulare, Calaveras, and El Dorado counties.

Table 18.--*Timber harvest of roundwood in California, by product, 1962*

Product[1]	Volume			
	MBF[2]	*Percent*	*M cu. ft.*	*Percent*
Sawlogs	4,751,900	85.3	688,681	86.2
Veneer logs and bolts	727,852	13.1	94,526	11.8
Pulpwood	22,452	.4	4,048	.5
Piling	2,203	(3/)	441	.1
Poles	9,650	.2	2,098	.3
Mine timbers	1,339	(3/)	279	(3/)
Shingle and shake, logs and bolts	2,464	.1	301	(3/)
Split products	24,844	.4	3,030	.4
Fuelwood	27,123	.5	5,904	.7
Round posts	112	(3/)	10	(3/)
Total	5,569,939	100.0	799,318	100.0

[1]Includes both live and dead timber from both commercial and noncommercial forest land.

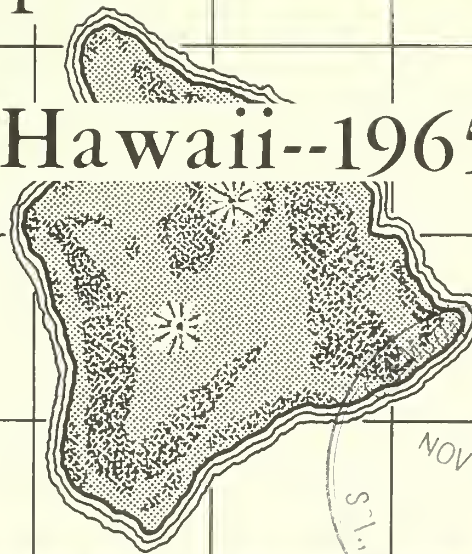
[2]International 1/4-inch log rule. Volumes were reported in local use log rules and other units of measure and were converted to International 1/4-inch log rule and to cubic foot equivalents as a common base.

[3]Less than 0.1 percent.

GPO 972-158

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 3 1966

lantation Timber
i the Island of Hawaii--1965



Robert E. Nelson
and
Nobuo Honda

acific Southwest Forest and Range
xperiment Station, Berkeley, California
orest Service
. S. Department of Agriculture

and

Division of Forestry,
Department of Land
and Natural Resources,
State of Hawaii

Foreword

This is the first of a series of reports about plantation timber on the different islands in the State of Hawaii. Summarized here are the results of an inventory of timber in planted forests on the Island of Hawaii. This inventory is a supplement to the initial Forest Survey of the State completed in 1963. The Survey indicated the importance of plantations as a timber resource but provided no details. This bulletin reports: (1) location and acreage of each planted stand, (2) species composition and age of stand, (3) timber volume and quality, and (4) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and the Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, Chief, Hawaii Forestry Research Center, Pacific Southwest Forest and Range Experiment Station. Nobuo Honda, Forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory and supervised the field work.

Many individuals aided in various phases of the survey. Special acknowledgment is due the field crews: Foresters W. Wong and E. Pung, and assistants S. Kamelamela, A. Chun, J. Hansen, B. Usegawa, J. Ah San, and M. Victorino of the Hawaii Division of Forestry.

E. M. Hornibrook, in charge of Forest Survey, Pacific Southwest Forest and Range Experiment Station, and Russell K. LeBarron, Forest Ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, Systems Analyst, Pacific Southwest Forest and Range Experiment Station, developed specifications for processing data through electronic computers. The Computing Center at the University of Hawaii processed the data.

Floyd M. Cossitt, Acting State Forester, retired, Max F. Landgraf, State Forester, and Libert Landgraf, District Forester, provided generous cooperation and assistance in the conduct of the survey.

Contents

The Authors

ROBERT E. NELSON is chief of the Station's Hawaii Research Center, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office. NOBUO HONDA, a native of Kona, Hawaii, received his bachelor's degree in forestry from Humboldt State College in 1960. As timber survey forester for the Hawaii Division of Forestry since April 1960, he has been assigned primarily to the forest inventory of the State.

Large acreages of native forest contain but small amounts of merchantable timber.

The first forest inventory in Hawaii showed that the bulk of the forest land and timber resources in the State[1] is on the Island of Hawaii. Of its total land area of 2.6 million acres, some 710,000 acres are commercial forest land with more than 600 million board feet of sawtimber (figs. 1, 2).

A large part of this timber resource is in native forest types. They occupy nearly 700,000 acres of the commercial forest land. The native ohia (Metrosideros collina) sawtimber totals about 360 million board feet, and koa (Acacia koa)--a more valuable species--totals some 110 million board feet. With sawtimber averaging only about 700 board feet per acre, the native forests are generally poorly stocked.

Planted forests contain a smaller but significant part of the total timber volume. Yields per acre average much greater in planted stands than in native stands. Also, timber in planted forests is generally of higher quality than native timber.

Most readily accessible, this plantation timber is likely to be of greater importance than native timber in any early expansion of milling operations. Therefore, we have made a stand-by-stand inventory to obtain information on plantation timber acreage, volume, quality, and ownership. Data compiled for each plantation stand are summarized in this report, and the section entitled Plantation Timber Resources briefly reviews information about forest plantations in each of four working circles into which the Big Island has been divided.

[1]Nelson, Robert E., and Wheeler, Philip R. Forest Resources of Hawaii--1961. Forestry Div., Dep. Land and Natural Resources, State of Hawaii, in cooperation with the Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr. 1963.

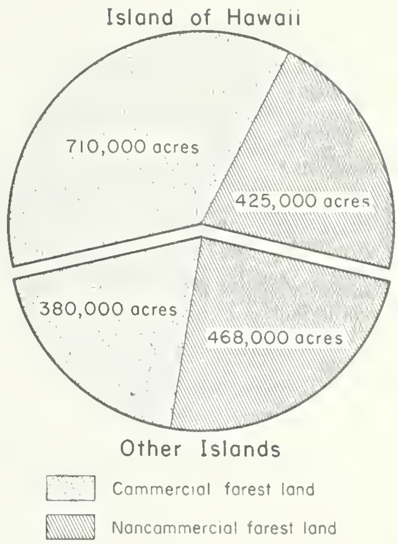


Figure 1.--Commercial and noncommercial forest land acreages on the Island of Hawaii and other islands, 1961.

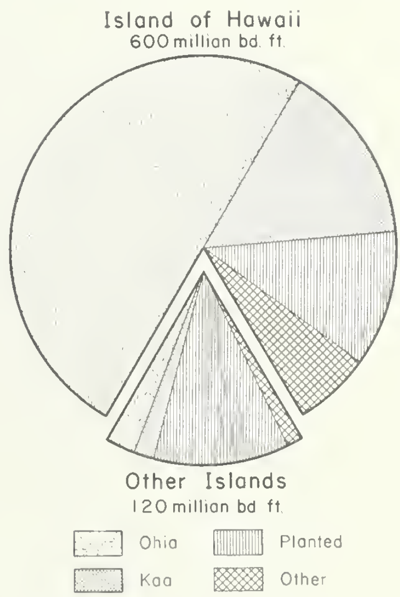


Figure 2.--Sawtimber volumes on the Island of Hawaii and other islands, 1961.

Highlights

Forest Plantation Area

Commercial forest plantations[2] on the Island of Hawaii total more than 13, 300 acres in stands from 2 acres to nearly 250 acres in size. About 7, 500 acres of these plantations are sawtimber stands (tables 1, 5, and fig. 3).[3] The remainder, some 5, 800 acres, are recently planted seedling, sapling, or poletimber stands. In addition to the commercial forest plantations there are about 2, 200 acres of plantations of noncommercial types.

Eucalypts are the principal tree species in older plantations. Nearly 6, 300 acres of the sawtimber stands are commercial eucalyptus type, of which 4, 700 acres are robusta eucalyptus. Only about 900 acres are commercial hardwood types other than eucalyptus. Some 300 acres are commercial conifer types.

Recent plantings have emphasized commercial hardwoods other than eucalyptus (tables 5, 6). There are about 5, 700 acres of seedling, sapling, or poletimber stands of these hardwood species; only about 100 acres of commercial eucalyptus types; and less than 50 acres of commercial conifer types.

Most of the forest plantations are in the Hilo-Hamakua Working Circle (table 5). Here are nearly 6, 000 acres of commercial sawtimber stands and an additional 4, 400 acres of seedling, sapling, or poletimber stands. The other three Working Circles--Kau, Kona, and Kohala combined have about 1, 500 acres of planted sawtimber stands and another 1, 500 acres of seedling, sapling, or poletimber stands.

[2]See definitions of terms in Appendix.

[3]Tables 1 through 20 are in the Appendix.

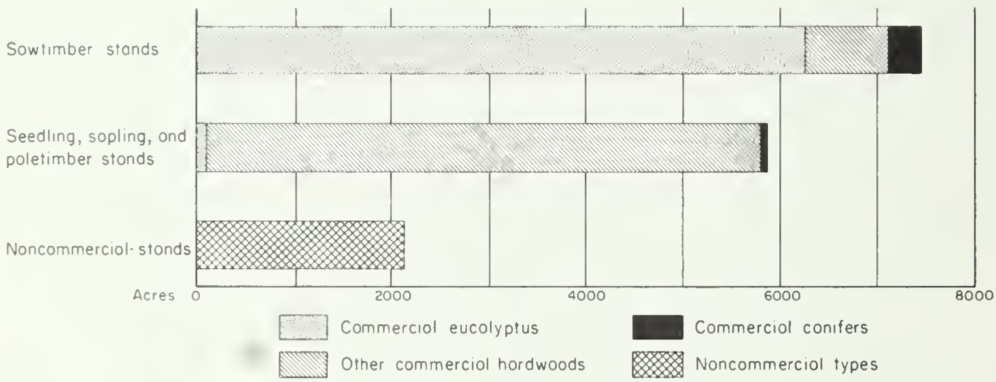


Figure 3.--Acreage of commercial and noncommercial plantation stands, by stand-size class and forest type, Island of Hawaii, 1965.

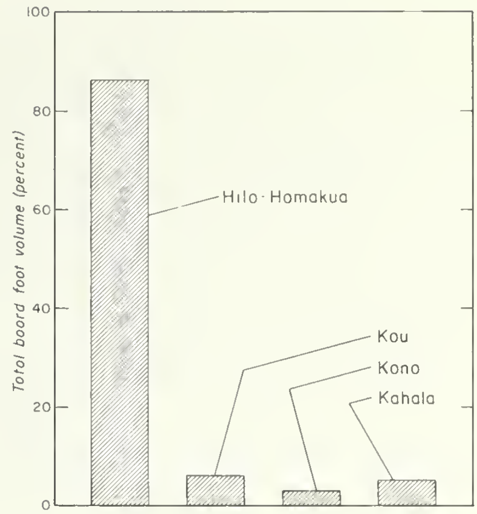


Figure 4.--Distribution of sawtimber volume in planted stands, by working circles, Island of Hawaii, 1965.

The State owns 65 percent of the acreage of commercial forest plantations (tables 2, 3, 4, 5). This amounts to more than 4,200 acres of sawtimber stands and about 4,500 acres of seedling, sapling, or poletimber stands. Hawaiian Homes[4] ownership amounts to 7 percent, or about 900 acres of the commercial forest plantations. Nearly 3,700 acres, or 28 percent of the planted commercial forests, are in private ownership.

About 1,200 acres or 54 percent of the noncommercial plantation types, are in State ownership, about 45 percent in private ownership, and only about 1 percent owned by Hawaiian Homes.

Forest Plantation Timber Volume

Planted forests on the Island of Hawaii contain nearly 117 million board feet of sawtimber (tables 7, 8). The volume in robusta eucalyptus sawtimber amounts to 69 percent of the total, or almost 81 million board feet. Sawtimber volume in all other eucalyptus species is 23 percent of the total. Hardwoods other than eucalypts total only 6.9 million board feet. Conifer sawtimber amounts to about 2.7 million board feet, mostly Norfolk-Island-pine.

Nearly two-thirds of the sawtimber volume is in trees 17 to 28 inches d.b.h. (table 10). Only 8 percent of the volume is in trees larger than 28 inches d.b.h.

Sawtimber stands in the Hilo-Hamakua Working Circle make up 86 percent of the total planted sawtimber volume, or about 100 million board feet (fig. 4 and table 8). This includes 71 million board feet of robusta eucalyptus and 24 million feet of other eucalyptus sawtimber. Stands in the Kau Working Circle have about 7 million board feet, the Kona Working Circle nearly 4 million board feet, and the Kohala Working Circle over 5 million board feet.

The State owns 56 percent of the plantation sawtimber: 65 million board feet (table 8 and fig. 5). This total includes about 58 million board

---

[4]Certain State-owned lands set aside and administered by the Hawaiian Homes Commission for the benefit of the people of Hawaiian ancestry.

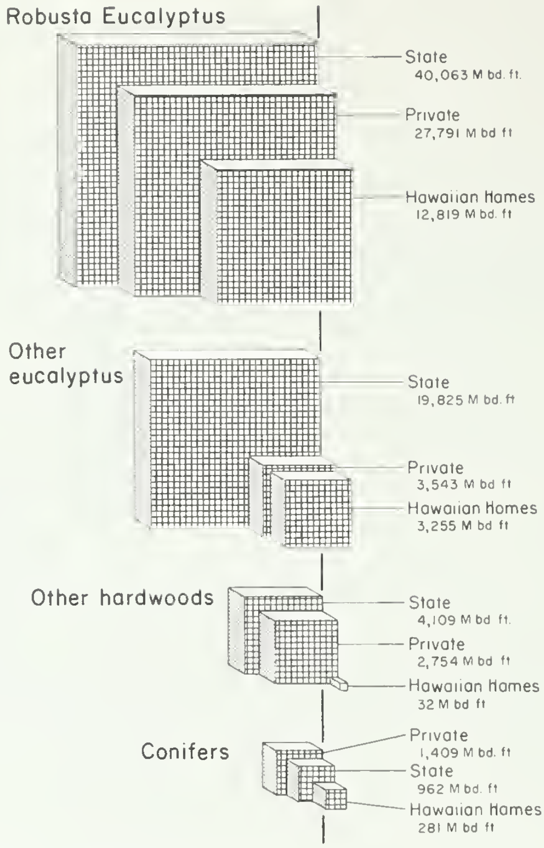


Figure 5.--Sawtimber volume in planted stands by species group and ownership class, Island of Hawaii, 1965.

feet in the Hilo-Hamakua Working Circle, of which 53 million feet are eucalyptus sawtimber. In the Kau, Kona, and Kohala Working Circles, the State owns some 7 million board feet of sawtimber, mostly in Kau.

The total growing stock volume in planted sawtimber stands amounts to about 25 million cubic feet (table 7). Nearly 17 million cubic feet of this volume is robusta eucalyptus. Other eucalypts total more than 5 million cubic feet of growing stock. The volume in other hardwoods is less than 2 million, and in conifers less than 1 million cubic feet.

Poletimber and sapling and seedling stands contain additional volumes of growing stock, but these were not measured.

Wood in cull trees in planted sawtimber stands totals nearly 1.3 million cubic feet (table 9). The 2,200 acres of noncommercial plantations hold an additional, much greater volume of wood in cull trees, but these stands were not measured.

Stand Yields

The average yield of sawtimber in planted sawtimber stands on the Island of Hawaii is about 16,000 board feet per acre. But yields vary widely with stand age, species, site, history and condition of the stand, and other factors. The highest stand average net volume was 79,720 board feet per acre in a robusta eucalyptus stand. The highest yield based on a single sample location was 95,400 board feet per acre in the same stand; the lowest was 411 board feet per acre.

Yields in planted sawtimber stands in the Hilo-Hamakua Working Circle average about 17,000 board feet per acre. This is much higher than in the Kau and Kona Working Circles but less than in the Kohala Working Circle, which averaged 19,000 board feet per acre.

Age of Stands

Only about 1,400 acres of commercial plantation timber stands are more than 40 years old (table 6). Practically all these older stands are north of Hilo in the Hilo-Hamakua Working Circle. Stands planted from 1926 to 1945 total nearly 6,100 acres. A large part of this acreage was planted between 1935 and 1941 by the Civilian Conservation Corps. Since 1945, more than 5,800 acres of commercial plantations have been established. By far, the greater part of these recent plantings has been done by the State Division of Forestry in the Waiakea Forest Reserve since 1960. Also important are the private plantings since 1957 in the Kona Working Circle, which total nearly 1,400 acres.

The Opportunity for Industrial Development

The Island of Hawaii has a large forest resource--44 percent of the land supports some kind of forest growth. More than 700,000 acres are commercial forest land capable of producing crops of timber. The volume of sawtimber in native forests and plantations totals over 600 million board feet.[5]

Because native forests are generally not well stocked, yields of merchantable timber are low. Nevertheless there has been almost continuous cutting of small amounts of koa and ohia over the past 60 years or more. Given improved processing techniques and equipment, greater technical knowledge about wood properties and characteristics for different uses, and improved market information and marketing methods--greater use of native timber is a likely prospect.

Planted forests have grown rapidly. In contrast to native forests, they now yield high per-acre volumes of sawtimber. The 117 million board feet of sawtimber on 7,500 acres of plantations amounts to about 20 percent of all sawtimber on the entire 700,000 acres of commercial forest land on the Big Island. Timber concentrated in these relatively accessible plantations offers a new opportunity for expanding the local lumber milling industry.

Most of the forestation that produced this new timber resource was not done to grow sawtimber. Trees were planted to control erosion, improve watershed cover, and provide fuelwood. Therefore, species planted were not necessarily selected on the basis of wood quality. Rapid growth was the main criterion. *Eucalyptus robusta*--a good sawtimber species--was highly favored. But so were several species that presently offer little or no potential for sawtimber, such as bluegum eucalyptus (*Eucalyptus globulus*), paper-bark (*Melaleuca leucadendron*), and ironwoods (*Casuarina* spp.).

[5] Nelson and Wheeler. See footnote 1.

The success of these early plantings shows that timber-production potentials are far greater than might be inferred from data on present volumes. We know that many valuable exotic species are adapted to the different forest sites. And that timber yields can be prodigious. Furthermore, management of native forests can greatly improve the yields and quality of timber. Under management, an average annual sawtimber growth of 1,000 board feet per acre can be expected from well-stocked planted and native forests on good sites.

If only 15 percent of the 700,000 acres of presently little-used and unmanaged commercial forest land were put under management, timber production would eventually amount to more than 100 million board feet annually. This is approximately the amount of wood now used (imported) in Hawaii each year. Three times this amount could be produced if half the commercial forest land on the Big Island were managed for timber crops.

Recent reforestation efforts of the State and of private land owners are trying to capitalize on this potential. Species are being selected with consideration for wood qualities and adaptability to specific sites. Plantings are made in large blocks and they are placing timber species on lands where native forests are of particularly poor quality, often just brush.

Since 1960, about 4,400 acres of land have been reforested by the State Division of Forestry in the Waiakea Forest Reserve of the Hilo Working Circle. About 1,400 acres of private land have been reforested in Kona since 1957. Australian redcedar and tropical ash, both high quality timber species, are the main trees planted. These stands will begin to yield merchantable timber in from 20 to 30 years.

This reforestation effort is being continued and hopefully will be expanded to bring a much larger forest area under management. The amount of reforestation accomplished during the next 10 years will determine in large part the amount of harvestable timber that will be available 30 to 40 years from now.

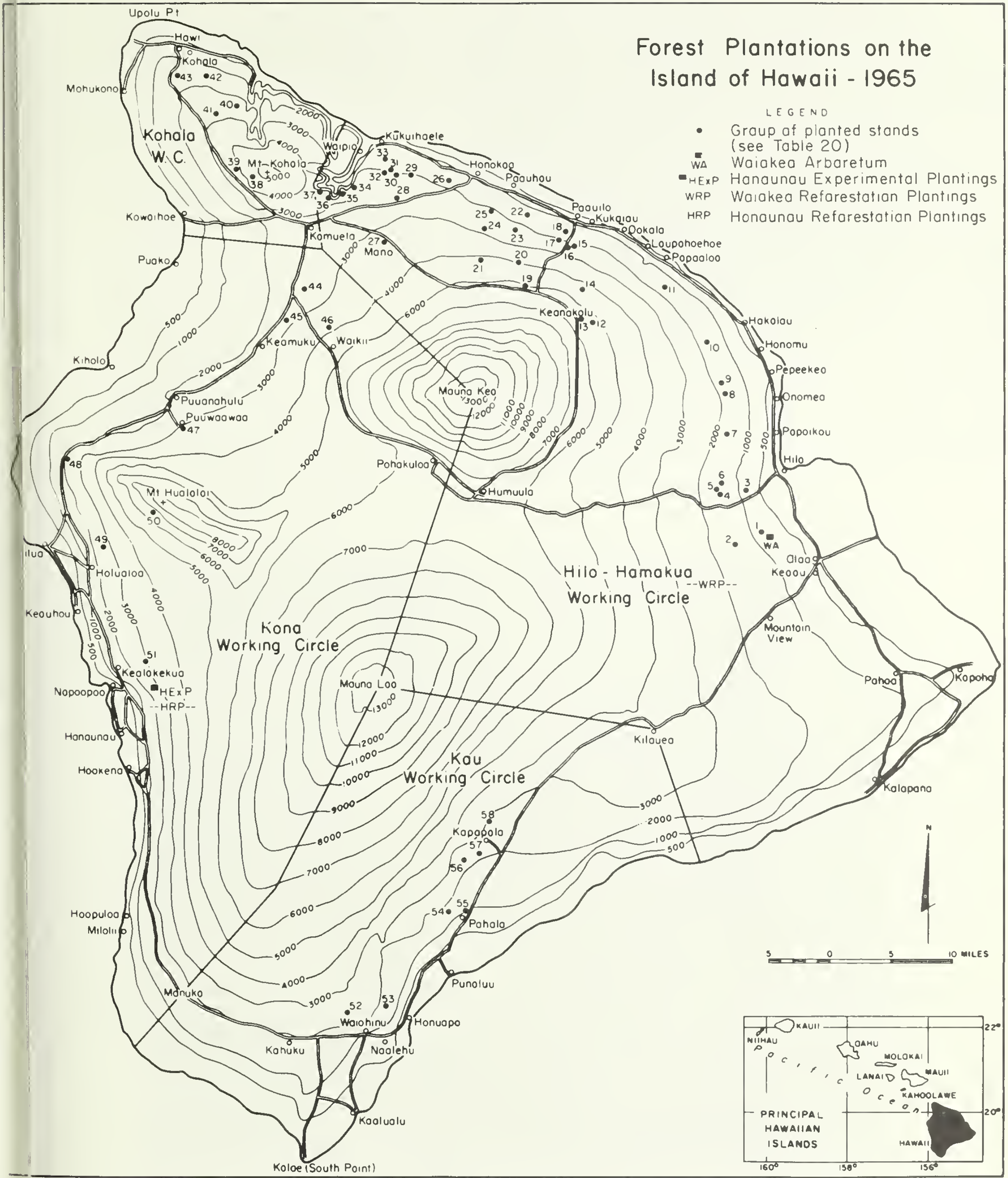
Plantation Timber Resources

Hilo-Hamakua Working Circle

The Hilo-Hamakua Working Circle makes up the northeast portion of the Island of Hawaii. (See map "Forest Plantations on the Island of Hawaii.") It is bordered on the north by Waipio Valley and on the south by Volcanoes National Park. The summits of Mauna Kea and Mauna Loa and the saddle between them form the western boundary. These boundaries enclose an area about 60 miles long and up to 25 miles wide. This is the windward side of the Big Island, with annual rainfall exceeding 100 inches on most of the land.

Sugar production is the most important industry in this area. Most lands below about 1,800 feet elevation that are suited to growing sugar cane are used for that purpose. Relatively little acreage is used for other cultivated crops, but fruit, nut, and flower production are important to the local economy.

Cattle graze on a large acreage throughout the area, the major pastures being on the slopes of Mauna Kea outside the forest reserves. Much of the grazed area is forest land.



Forest Plantations on the Island of Hawaii - 1965
LEGEND
Group of planted stands (see Table 20)
WA Waiakea Arboretum
HExP Hanaunau Experimental Plantings
WRP Waiakea Reforestation Plantings
HRP Honaunau Reforestation Plantings
Kohala W.C.
Hilo - Hamakua Working Circle
Kona Working Circle
Kau Working Circle
Mauna Kea
Mauna Loa
Mt Hualalai
Mt Kohala
Kilauea
Upolu Pt
Hawi
Kohala
Mahukona
Waipio
Kukuihaele
Honokaa
Paauhau
Paauilo
Kukaiau
Ookala
Laupahoehoe
Papaaloa
Kawaihae
Kamuela
Mana
Puako
Keamuku
Waikii
Keanakolu
Hakalau
Honomu
Pepeekeo
Onomea
Papaikou
Hilo
Humuula
Pohakuloa
Kiholo
Puuanahulu
Puuwaawaa
Holualoa
Keauhou
Kealakekua
Napoopoo
Honaunau
Hookena
Hoopuloa
Milolii
Manuka
Kahuku
Waiohinu
Naalehu
Honuapo
Punaluu
Pahala
Kapapala
Kalapana
Kapoho
Pahoa
Mountain View
Keaau
Olaa
Kaalualu
Kalae (South Point)
N
5 0 5 10 MILES
PRINCIPAL HAWAIIAN ISLANDS
KAUAI
NIIHAU
OAHU
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
Pacific Ocean
22°
20°
160°
158°
156°

Eucalyptus robusta is the most abundant planted timber. This robusta stand (No. 8038) averages nearly 26,000 board feet of sawtimber per acre.

Tropical ash has not shown consistent high yields like the eucalypts, but the wood is of high value for furniture and cabinetry. In this stand (No. 8166) the net volume averages more than 14,000 board feet per acre.

There are extensive forests in this working circle. The commercial forest land amounts to about 360, 000 acres. Most of it is native ohia forest, which has offered little incentive for timber operations in the past. There is also a large acreage of koa forest in this working circle, much of it decadent.

Forest Plantation Area

Within the Hilo-Hamakua Working Circle are about 11, 800 acres of forest plantations. They include 6, 000 acres of sawtimber stands, 4, 400 acres of seedling, sapling, and poletimber stands, and 1, 400 acres of noncommercial types (table 1, 5). Many of these planted forests are in the Forest Reserves[6] adjacent to the upper edges of the cane fields. Also, many stands are in forests outside the Reserves, scattered throughout the general areas of canefields and pastured land.

The bulk of the planted sawtimber stands are within 3 miles of the main highway between Hilo and Waipio Valley. Also, most of the noncommercial plantations are in this area, generally northwest of Hilo. The seedling, sapling, and poletimber stands, on the other hand, are concentrated southwest of Hilo in the Waiakea, Upper Waiakea, and Olaa Forest Reserves.

Forest Types

Robusta eucalyptus type makes up 67 percent of the acreage of planted sawtimber stands (tables 5, 19). Saligna eucalyptus and other commercial eucalyptus types comprise about 19 percent of the acreage. Other commercial hardwood species such as tropical ash and silk-oak total about 10 percent, and commercial conifers such as sugi and Norfolk-Island-pine make up the remaining 4 percent of the area.

Most of the 4, 400 acres of seedling, sapling, and pole stands are of tropical ash and Australian redcedar. Queensland maple and some eucalypts are also in these stands.

The noncommercial plantation types are mostly bluegum eucalyptus, *Casuarina* spp., and paper-bark, but they include some Monterey cypress.

Timber Volume

Merchantable planted sawtimber totals just over 100 million board feet (table 11). Seventy percent of this is robusta eucalyptus. Saligna (13 percent) and other commercial eucalypts (11 percent) make up most of the remainder. Silk-oak, tropical ash, Australian redcedar, and other commercial hardwoods total just over 4 million board feet. The volume in commercial conifers such as Norfolk-Island-pine and sugi totals just under 2 million board feet.

Almost half the sawtimber volume is in trees 19. 0 to 28. 9 inches d. b. h. (table 11).

Quality

Saligna eucalyptus has the highest quality logs, based on Standard Hardwood Log Grades (table 15).[7] A remarkable 46 percent of the saligna volume is in grade 1 sawlogs, an additional 23 percent in grade 2 logs.

---

[6]Public and private lands administered by the State for the management and protection of watersheds and other forest values.

[7]Quality of wood as determined by physical properties and mechanical characteristics inherent in species is not a consideration in this classification.

Robusta eucalyptus also has fairly high log quality with 47 percent of the volume in grade 1 and 2 sawlogs. Other commercial eucalypts are comparable to robusta in log quality.

Tropical ash has about 40 percent of total volume in grade 1 and 2 logs. Silk-oak and other hardwoods are of lower log quality, however, with less than 25 percent of the volume in grade 1 and 2 logs.

Conifer species were not log graded.

Ownership

The State of Hawaii is by far the largest owner of forest plantations in the Hilo-Hamakua Working Circle (table 5).[8] Of the more than 10,000 acres of commercial types tallied, the State owns 76 percent, or nearly 7,900 acres. Additional public ownership is Hawaiian Homes land amounting to just over 900 acres. Only 15 percent, or about 1,550 acres, is in private ownership.

In volume, the State owns a lesser proportion of the timber (table 15) because a substantial area of the State-owned plantations are recently planted seedling, sapling, and poletimber stands. Nevertheless, the State owns about 57 percent of the sawtimber, amounting to nearly 58 million board feet. Hawaiian Homes owns about 16 million board feet, and there are nearly 27 million board feet in private ownership.

Yields

Average stand yields per acre range from a high of nearly 80,000 board feet to less than 750 board feet. Eucalyptus stands in general, and older robusta and saligna stands in particular, have the highest yields. Other hardwoods generally show lowest yields. The average per acre yield for all species in the working circle is about 17,000 board feet.

Timber Cutting Potentials

Plantation timber in the Hilo-Hamakua Working Circle can provide a base for substantial lumber milling operations. A harvest of 5 million board feet of sawlogs per year could be continued for more than 20 years, based on present resources alone. An even larger cut may be possible because timber growth is boosting yields in these plantations.

Assuming a growth of only 500 board feet of sawtimber per acre per year, the nearly 6,000 acres of older plantations would support a sustained annual cut of about 3 million board feet. The acreage now in seedling, sapling, and poletimber stands will yield additional merchantable sawtimber in about 25 years. From then on, the sustained yield from the more than 4,400 acres in these younger stands will amount to more than 2 million board feet annually. The allowable annual cut in these plantations during the first rotation is the sum of annual growth and a portion of the present inventory, assuming the present inventory will be liquidated during the rotation period. Forestation efforts are expected to be continued and even expanded, providing an increasing plantation timber resource base for a lumber milling industry in this working circle.

The large volume of ohia and koa timber in the native forests are an additional resource to support a milling industry. There is little doubt that greater utilization of the native timber resource will come about with improved technology and marketing attendant to a large milling operation.

[8] Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand the ownership designation may be in error, although overall ownership statistics are probably not greatly affected by this kind of error.

There is more volume of Norfolk-Island-pine sawtimber than any other conifer species. Here, in stand No. 8029, the average yield is more than 27,000 board feet per acre.

Australian redcedar (seedlings and saplings in foreground) has been highly favored in recent forestation. Large ohia trees in background were reserved during bulldozing for site preparation.

This 45-year-old Eucalyptus saligna tree, growing on Palani Ranch pasture in Kona, is probably the tallest hardwood tree in the United States. Total height is 235 feet, and diameter at breast height is 48.8 inches.

Wind has caused some loss of timber, as in this robusta stand in Kau (stand No. 8216) where net volume averages 9,000 board feet per acre.

Some forest plantations are intermingled with sugar cane fields, as are these in Kau.

Ironwood (dark trunks) and paper-bark are examples of noncommercial plantation types.

Kau Working Circle

The Kau Working Circle lies on the southeast slope of Mauna Loa, southwest of the Volcanoes National Park. It is about 40 miles long and 20 miles wide. Much of the working circle has an annual rainfall of less than 30 inches and thin, rocky soils. There are extensive areas of raw lava flows.

Cattle ranching occupies a large part of the land. Most of the more arid areas, and some forest land, is grazed. Sugar production is probably the most important industry. Most arable land between 1, 000 feet and 3, 000 feet is used for sugar cane. Crops like macadamia nuts and coffee are important locally, but occupy little acreage.

There are about 120, 000 acres of commercial forest land in this working circle, and large areas of noncommercial forest land. Most of the commercial forest land is native ohia forest, which has offered little incentive to exploitation in the past. Most of it lies above the sugar cane plantations.

Forest Plantation Area

This inventory tallied slightly more than 800 acres of planted forests in the Kau Working Circle (tables 1, 5). Nearly 750 acres are sawtimber stands; about 50 acres are noncommercial types. Most of these plantations are at Wood Valley, Middle Moaula, or Kiolakaa, adjacent to sugar cane fields. Very little acreage of the planted forests is in the Forest Reserves.

The area of forest plantations has decreased rapidly since 1955. With the pressure for more acreage of sugar cane, many planted stands have been cut or bulldozed and the land converted to sugar production. There has been only minor salvage of timber during the land clearing operations because of the small size of the island sawmilling industry and problems of timing.

Forest Types

Robusta eucalyptus is the major plantation forest type, occupying nearly 600 acres, or 79 percent of the area of sawtimber stands (tables 5, 19). Saligna eucalyptus accounts for 6 percent of the area, and other commercial eucalypts about 9 percent. Silk-oak and other commercial hardwood plantations occupy less than 50 acres.[9] There are no commercial conifer type forest stands.

The noncommercial plantation types are mainly ironwood and bluegum eucalyptus.

Timber Volume

Merchantable planted sawtimber in the Kau Working Circle totals slightly more than 7 million board feet (table 12). Eighty-six percent of this volume, or about 6 million feet, is robusta eucalyptus. The volume in saligna eucalyptus is about one-half million board feet. Other commercial eucalypts and other commercial hardwoods (mainly silk-oak) each total about one-quarter million board feet.

More than 60 percent of the sawtimber volume is in trees 17. 0 to 28. 9 inches d. b. h.

---

[9] There are rather extensive areas of naturalized, young silk-oak stands in the working circle.

Quality

Saligna eucalyptus sawtimber is of better quality than that of other species, based on proportion of volume in grades 1 and 2 factory lumber logs. Thirty-nine percent of the saligna sawtimber is in grade 1, and 33 percent in grade 2 logs (table 16). Only 20 percent of the robusta sawtimber volume is in grade 1 logs, and 17 percent in grade 2 logs; 63 percent is in grades 3 and 4. Other commercial eucalypts are comparable in quality to robusta. Only 3 percent of the silk-oak sawtimber is in grade 1 logs, 26 percent is in grade 2, and 71 percent is in grade 3 and 4 logs.

Ownership

The State of Hawaii owns more than half the planted timber in the Kau Working Circle (table 5).[10] This amounts to just over 400 acres of sawtimber stands with about 4.2 million board feet of timber (table 16). The rest of the planted timber, nearly 350 acres of sawtimber stands containing almost 2.9 million board feet, is in private ownership.

Yields

The highest average per-acre volume in a sawtimber stand is in a robusta stand containing nearly 36,000 board feet per acre. The lowest yield is in a cutover eucalyptus stand with a residual volume of about 2,600 board feet per acre.

Some wind damage has hit most planted stands in this working circle. Uprooting and stem breakage has reduced volume in about three-fourths of the stands. In some stands this "loss" may amount to 75 percent of the volume.

Timber Cutting Potentials

Plantation timber in the Kau Working Circle is not adequate in itself to sustain full-time operation of even a small mill. And the native timber and timber in young forests of naturalized exotics do not offer much additional resource base for milling operations. There have been no forestation efforts here in recent years, so there are no young planted stands to provide additional timber in the future.

Put the existing plantation timber can supplement resources for a milling operation in the Hilo-Hamakua Working Circle. A substantial mill at Hilo, for example, would provide a market for logs, cants, or rough lumber trucked from Kau. A portable mill might be operated temporarily in the Kau Working Circle as a satellite to a larger milling and processing complex in the Hilo-Hamakua Working Circle.

Kona Working Circle

The Kona Working Circle takes in the land on the west slopes of Mauna Kea and Mauna Loa, sweeping down to the ocean. From Manuka on the south, it extends northward to Kamuela. The area is about 60 miles long and 20 miles wide. Topography is steep in parts, often rough and rocky, and there are large areas of recent lava flows. Large parts of the area have an annual rainfall of less than 30 inches.

Cattle and coffee are the major agricultural products in this area. Tourism is a fast-growing business, centered in resort communities like Kailua.

---

[10] See footnote 8.

Commercial forest land totals some 210,000 acres. Most of it lies in a belt extending south from Mt. Hualalai between 1,500 feet and 6,000 feet elevation, where annual rainfall ranges from 30 to 100 inches. The commercial forest land is not well stocked with timber in general, and much of it is grazed, open forest. Ohia is the predominant forest type and has offered little economic incentive for utilization in the past. Koa forests have been exploited and, although koa trees are important components of the forests at higher elevations, koa forests are much less extensive now than formerly, owing to land clearing for cattle production.

Forest Plantation Area

Planted forests in the Kona Working Circle total slightly more than 2,400 acres (tables 1, 5). They include more than 500 acres of sawtimber stands, more than 1,400 acres of seedling, sapling, and pole stands, and nearly 500 acres of noncommercial types. Most of the commercial forest plantations are in the forest reserves, whereas most of the acreage of noncommercial types is outside the reserves.

The Honuaula and North Kona Forest Reserves on the slopes of Mt. Hualalai include about 325 acres, or 63 percent of the acreage of sawtimber stands. The acreage of seedling, sapling, and poletimber stands is concentrated in the Honaunau Forest Reserve. Most of the noncommercial plantations are in the north end of the working circle, where annual rainfall is less than 25 inches.

Forest Types

Sawtimber stands are mainly eucalyptus types and silk-oak type (tables 5, 19): about 200 acres of robusta type, 150 acres of other commercial eucalypts, and 100 acres of silk-oak. There is a very small acreage of other commercial hardwood and conifer types.

Seedling, sapling, and poletimber stands are predominantly of Australian redcedar and tropical ash. Only small acreages of these recent plantings are in eucalypts and conifers.

The noncommercial plantations are mainly of eucalyptus species on very dry sites, unsuited for producing sawtimber crops.

Timber Volume

Sawtimber in forest plantations in the Kona Working Circle totals only 3.9 million board feet (table 13). About 34 percent of this volume, or 1.3 million feet, is robusta eucalyptus. Other eucalypts make up 29 percent. Silk-oak volume totals about 1.1 million board feet. There is an additional small volume of tropical ash and other commercial hardwoods. Commercial conifers, mainly sugi, total nearly one-fourth million board feet.

Two-thirds of the sawtimber volume is in trees less than 19 inches d.b.h.

Quality

Based on log grades, robusta timber is of better quality than other species in this working circle (table 17). Whereas about 38 percent of the robusta sawtimber is in grade 1 and 2 logs, less than 3 percent of the volume of other eucalypts and only 11 percent of the volume of other hardwoods is in grade 1 and 2 logs.

Ownership

Most of the acreage of forest plantations in the Kona Working Circle is in private ownership, but the State owns the bulk of the present sawtimber stands (table 5).[11] The State owns about 350 acres of sawtimber stands with 2.5 million board feet of sawtimber, mostly eucalyptus (table 17). About 160 acres of sawtimber stands with 1.4 million board feet are in private ownership. Most of this is silk-oak.

Seedling, sapling, and poletimber stands are mostly in private ownership, the State owning only about 40 acres out of more than 1,400 acres of these recent plantings.

Yields

The average yield per acre in planted sawtimber stands in the Kona Working Circle is only about 7,500 board feet. The highest average yield is in a stand of sugi with nearly 20,000 board feet per acre. One silk-oak stand averages nearly 11,000 board feet per acre. The low average yield in eucalyptus stands--about 7,000 board feet per acre--is due partly to wind damage. In the North Kona watershed especially, there is a high incidence of windfall because soils are shallow and underlain by pahoehoe.

Timber Cutting Potentials

There is little immediate prospect for any significant milling operations based on plantation timber. Although markets for logs may develop in Hilo or elsewhere, making it feasible to harvest accessible stands, such operations would be short term because of the limited volume. Most sawtimber stands are relatively inaccessible, and it does not seem likely that the limited timber volumes would justify the cost of access roads.

The acreage now in seedling, sapling, and poletimber stands will yield merchantable sawtimber in about 25 years. Also, the private forestation program underway in this working circle is expected to continue. The prospects for milling operations depend on the extent of forestation efforts and the extent to which the native timber can be utilized.

Kohala Working Circle

The Kohala Working Circle covers the northern peninsula of the Big Island, northwest from Kamuela. The smallest of the four working circles on the Island, it is about 20 miles long and 12 miles wide. Sugar and beef are the main products from this area.

There are only 20,000 acres of commercial forest land in this working circle. Most of this is scrubby ohia forest. There are also many areas of noncommercial forest land--part of it brushy kiawe (Prosopis pallida) forest in dry areas, part native forest on very steep, rocky sites or swampy areas on Mt. Kohala.

Forest Plantation Area

The total forest plantation area is only 490 acres (table 1, 5). Of this, only 280 acres are commercial types, and 210 acres noncommercial. The greater part of the commercial plantations is in the Kohala forest reserve; most of the noncommercial types are outside the reserve.

Most planted forests are adjacent to canefields or pastures and therefore are relatively easy to reach, but steep topography and wet soil conditions often hinder access.

Forest Types

Robusta eucalyptus is the predominant plantation type, totaling some 140 acres in sawtimber stands (tables 5, 19). There are also small acreages of other commercial eucalyptus types. Other commercial hard-

[11] See footnote 8.

wood stands total less than 100 acres, and only a few acres are in commercial conifers.

The noncommercial plantings are predominantly ironwood with just a small acreage of paper-bark.

Timber Volume

Plantation sawtimber in this working circle totals 5.2 million board feet (table 14). About 66 percent, or 3.4 million feet of the sawtimber is eucalyptus. Robusta alone totals more than 2.7 million board feet. Other commercial hardwoods, mainly Molucca albizzia, make up nearly 1.3 million board feet. Norfolk-Island-pine sawtimber totals nearly one-half million board feet, and there is a very small volume in other conifer species.

Nearly half the volume of sawtimber is in trees 17.0 to 28.9 inches d.b.h.

Quality

It appears that eucalyptus trees are rougher or limbier in general in this than in other working circles. Only about 25 percent of the eucalyptus timber is in grade 1 and 2 logs; 51 percent is in grade 4, or tie and timber logs (table 18). Molucca albizzia timber is in larger diameter trees on the average, and 88 percent of the volume is in grade 1 and 2 logs.

Ownership

Nearly 80 percent of the commercial forest plantation acreage is privately owned (table 5).[12] This amounts to nearly 220 acres with 4.4 million feet of sawtimber (table 18). State and Hawaiian Homes ownership combined amounts to about 60 acres, with some three-fourths million board feet of sawtimber.

Most of the noncommercial plantation acreage is also privately owned, but a small acreage is in Hawaiian Homes ownership.

Yields

The average sawtimber yield in this working circle is slightly more than 19,000 board feet per acre. The highest average per-acre volume is in a small stand of Eucalyptus citriodora, yielding over 35,000 board feet per acre.

Timber Cutting Potentials

The Kohala Working Circle has too little plantation timber to support full-time operation of even a small sawmill. The sawtimber in native forests is in such small amounts and so scattered that it is unimportant.

The present plantation timber can, however, provide a supplemental supply for a mill in the Hilo-Hamakua Working Circle. A substantial operation in that working circle, for example, might provide a profitable market for logs from the more accessible high-quality timber stands.

[12] See footnote 8.

Appendix

Definitions

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground.

Commercial forest land: Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.

Noncommercial forest land: (a) Productive-reserved forest land withdrawn from timber use through statute or administrative regulation, and (b) unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of the growing space is occupied by planted commercial species (usually exotic), regardless of native species predominance.

Commercial forest plantation: A plantation of commercial tree species on commercial forest land.

Noncommercial forest plantation: A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuelwood or fence posts are excluded. The following were tallied on plots:

Scientific Name	Common Name
Acacia koa	koa
Albizia falcata	Molucca albizzia
Alnus nepalensis	Nepal alder
Araucaria excelsa	Norfolk-Island-pine
Chamaecyparis lawsoniana	Port-Orford-cedar
Cryptomeria japonica	sugi
Eucalyptus citriodora	lemon eucalyptus
Eucalyptus deanei	Deane eucalyptus
Eucalyptus maideni	Maiden-gum eucalyptus
Eucalyptus microcorys	tallowwood eucalyptus
Eucalyptus paniculata	gray ironbark eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus resinifera	kinogum eucalyptus
Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Metrosideros collina	ohia

Scientific Name	Common Name
Pithecellobium saman	monkey-pod
Sequoia sempervirens	redwood
Syncarpia glomulifera	turpentine-tree
Taxodium distichum	baldcypress
Terminalia myriocarpa	jhalna
Thuja plicata	western redcedar
Toona ciliata var. australis	Australian redcedar (toon)
Tristania conferta	brushbox

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following were tallied on plots:

Scientific Name	Common Name
Aleurites moluccana	kukui
Casuarina spp.	ironwoods
Cheirodendron sp.	'olapa
Cupressus macrocarpa	Monterey cypress
Delonix regia	royal poinciana
Eucalyptus globulus	bluegum eucalyptus
Eucalyptus sp.	unidentified eucalyptus
Ficus spp.	figs
Jacaranda minosifolia	jacaranda
Melaleuca leucadendron	paper-bark
Myoporum sandwicense	naio
Straussia sp.	kopiko

Hardwoods: Dicotyledonous trees, usually broadleaved.

Softwoods: Coniferous trees, usually evergreen, having needle or scale-like leaves.

Forest types: Planted stands which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type or tropical ash type. Otherwise they are designated:

> Commercial eucalyptus type: Planted stands predominantly of eucalyptus species, in which other hardwoods or conifers comprise less than 25 percent of the stand.
>
> Commercial hardwood type: Planted stands predominantly of hardwoods other than the eucalypts in which conifers or eucalypts comprise less than 25 percent of the stand.
>
> Commercial conifer type: Planted forests predominantly of conifers (e.g. Norfolk-Island-pine, sugi, pines, and redwood) in which eucalypts or other hardwoods comprise less than 25 percent of the stand.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

Sawtimber trees: Live trees of commercial species of at least 11.0 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.

Poletimber trees: Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.

Saplings and seedlings: Live trees of commercial species between 1.0 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Merchantable sawtimber: Wood in trees defined as sawtimber trees.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections, V equals 0.905 $(0.22D^2 - 0.71D)$.

Sawtimber volume: The net volume of the saw-log portion of sawtimber trees, in board feet, International 1/4-inch rule.

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable sawlog cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5.0 inches d.b.h. or larger, from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches.

Stand-Size Classes

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing stock.

Nonstocked: Commercial forest lands less than 10 percent stocked with growing stock trees.

Miscellaneous

Diameter breast height (d. b. h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as sawlogs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[1] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, these are usually inherent in a species.

Working Circle: A term of convenience understood by timber operators and foresters as referring to a relatively large land area for management, administrative, or economic purposes.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand by plantation stand. First, individual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured on the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could

[1] U.S. Forest Products Laboratory. Hardwood log grades for standard lumber--proposals and results. U.S. Forest Serv. Forest Prod. Lab. Rep. 1737, 15 pp., illus. 1953.

be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared electronic computer program. Tree measurements were converted to meaningful volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreage of the stand. The computer output consisted of tabular data for each stand and summaries of stand data by forest reserves. Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands.

The accuracy goal for this inventory was $\pm$ 20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. The reliability of estimates for each forest reserve are shown below in terms of sampling errors to which the estimates are liable, two chances out of three.

Forest Reserve	Total volume (thousand bd. ft.)	Sampling error (percent)
Hamakua	52,885	7.5
Hilo	24,507	9.6
Honuaula	1,255	34.6
Kau	1,321	15.0
Kohala	8,227	5.6
Manowaialee	2,048	19.0
North Kona Watershed	1,108	9.3
Waiakea	1,109	3.7
Outside Forest Reserve	22,240	7.8

Table 1.--Area of forest plantations for all ownerships by forest type, working circle, and forest reserve, Island of Hawaii, 1965

Working circle and forest reserve	Forest type: Commercial eucalypts	Forest type: Other commercial hardwoods	Forest type: Commercial conifers	Total commercial types	Total noncommercial types	Total all types
	Acres					
Hilo-Hamakua						
Hamakua	2,152	322	69	2,543	69	2,612
Hilo	1,387	104	110	1,601	14	1,615
Kohala	287	52	88	427	--	427
Manowaialee	102	88	--	190	21	211
Waiakea	133	851	--	984	--	984
Upper Waiakea	--	2,233	--	2,233	--	2,233
Olaa	12	1,178	--	1,190	--	1,190
Outside Reserve	999	166	33	1,198	1,294	2,492
Total	5,072	4,994	300	10,366	1,398	11,764
Kau						
Kau	148	14	--	162	--	162
Outside Reserve	554	37	--	591	63	654
Total	702	51	--	753	63	816
Kona						
Kahaluu	2	9	--	11	--	11
Honaunau	67	1,312	--	1,379	--	1,379
Honuaula	143	25	49	217	--	217
North Kona Watershed	148	--	--	148	--	148
Outside Reserve	63	116	9	188	513	701
Total	423	1,462	58	1,943	513	2,456
Kohala						
Kohala (West)	139	75	21	235	16	251
Outside Reserve	31	9	5	45	194	239
Total	170	84	26	280	210	490
Total all working circles	6,367	6,591	384	13,342	2,184	15,526

Table 2.--Area of forest plantations in State ownership by forest type, working circle, and forest reserve, Island of Hawaii, 1965

Working circle and forest reserve	Forest type: Commercial eucalypts	Forest type: Other commercial hardwoods	Forest type: Commercial conifers	Total commercial types	Total noncommercial types	Total all types
	Acres					
Hilo-Hamakua						
Hamakua	1,121	303	--	1,424	63	1,487
Hilo	1,114	104	110	1,328	--	1,328
Kohala (East)	100	52	86	238	--	238
Manowaialee	76	88	--	164	--	164
Waiakea	133	851	--	984	--	984
Upper Waiakea	--	2,233	--	2,233	--	2,233
Olaa	12	1,178	--	1,190	--	1,190
Outside Reserve	199	139	--	338	1,049	1,387
Total	2,755	4,948	196	7,899	1,112	9,011
Kau						
Kau	148	14	--	162	--	162
Outside Reserve	251	--	--	251	38	289
Total	399	14	--	413	38	451
Kona						
Honuaula	143	25	49	217	--	217
North Kona Watershed	148	--	--	148	--	148
Outside Reserve	6	--	--	6	2	8
Total	297	25	49	371	2	373
Kohala						
Kohala (West)	37	--	--	37	--	37
Outside Reserve	--	--	--	--	--	--
Total	37	--	--	37	--	37
Total all working circles	3,488	4,987	245	8,720	1,152	9,872

Table 3.--Area of forest plantations in Hawaiian Homes ownership by forest type, working circle, and forest reserve, Island of Hawaii, 1965

Working circle and forest reserve	Forest type			Total commercial types	Total noncommercial types	Total all types
	Commercial eucalypts	Other commercial hardwoods	Commercial conifers			
	Acres					
Hilo-Hamakua						
Hamakua	840	--	36	876	--	876
Kohala (East)	11	--	2	13	--	13
Outside Reserve	15	12	3	30	16	46
Total	866	12	41	919	16	935
Kau	--	--	--	--	--	--
Kona	--	--	--	--	--	--
Kohala						
Kohala (West)	18	--	8	26	16	42
Outside Reserve	--	--	--	--	--	--
Total	18	--	8	26	16	42
Total all working circles	884	12	49	945	32	977

Table 4.--Area of forest plantations in private ownership by forest type, working circle, and forest reserve, Island of Hawaii, 1965

Working circle and forest reserve	Forest type: Commercial eucalypts	Forest type: Other commercial hardwoods	Forest type: Commercial conifers	Total commercial types	Total noncommercial types	Total all types
	Acres					
Hilo-Hamakua						
Hamakua	191	19	33	243	6	249
Hilo	273	--	--	273	14	287
Kohala (East)	176	--	--	176	--	176
Manowaialee	26	--	--	26	21	47
Outside Reserve	785	15	30	830	229	1,059
Total	1,451	34	63	1,548	270	1,818
Kau						
Kau	--	--	--	--	--	--
Outside Reserve	303	37	--	340	25	365
Total	303	37	--	340	25	365
Kona						
Kahaluu	2	9	--	11	--	11
Honaunau	67	1,312	--	1,379	--	1,379
Outside Reserve	57	116	9	182	511	693
Total	126	1,437	9	1,572	511	2,083
Kohala						
Kohala (West)	84	75	13	172	--	172
Outside Reserve	31	9	5	45	194	239
Total	115	84	18	217	194	411
Total all working circles	1,995	1,592	90	3,677	1,000	4,677

Table 5.--Area of commercial forest plantations by forest type, ownership class, stand-size class, and working circle, Island of Hawaii, 1965

Working circle and stand-size class	Commercial eucalypts: State	Commercial eucalypts: Hawaiian Homes	Commercial eucalypts: Private	Commercial eucalypts: All ownerships	Other commercial hardwoods: State	Other commercial hardwoods: Hawaiian Homes	Other commercial hardwoods: Private	Other commercial hardwoods: All ownerships	Commercial conifers: State	Commercial conifers: Hawaiian Homes	Commercial conifers: Private	Commercial conifers: All ownerships	All types and ownerships
	Acres												
Hilo-Hamakua													
Sawtimber	2,720	866	1,451	5,037	558	12	34	604	196	39	60	295	5,936
Pole timber	--	--	--	--	--	--	--	--	--	--	3	3	3
Seedling and sapling	35	--	--	35	4,390	--	--	4,390	196	2	--	2	4,427
All classes	2,755	866	1,451	5,072	4,948	12	34	4,994	196	41	63	300	10,366
Kau													
Sawtimber	399	--	303	702	8	--	37	45	--	--	--	--	747
Pole timber	--	--	--	--	6	--	--	6	--	--	--	--	6
Seedling and sapling	--	--	--	--	--	--	--	--	--	--	--	--	--
All classes	399	--	303	702	14	--	37	51	--	--	--	--	753
Kona													
Sawtimber	297	--	57	354	25	--	116	141	8	--	9	17	512
Pole timber	--	--	--	--	--	--	--	--	41	--	--	41	41
Seedling and sapling	--	--	69	69	--	--	1,321	1,321	--	--	--	--	1,390
All classes	297	--	126	423	25	--	1,437	1,462	49	--	9	58	1,943
Kohala													
Sawtimber	37	18	115	170	--	--	75	75	--	8	18	26	271
Pole timber	--	--	--	--	--	--	9	9	--	--	--	--	9
Seedling and sapling	--	--	--	--	--	--	--	--	--	--	--	--	--
All classes	37	18	115	170	--	--	84	84	--	8	18	26	280
All Working Circles													
Sawtimber	3,453	884	1,926	6,263	613	12	240	865	204	47	87	338	7,466
Pole timber	--	--	--	--	6	--	9	15	41	--	3	44	59
Seedling and sapling	35	--	69	104	4,390	--	1,321	5,711	--	2	--	2	5,817
All classes	3,488	884	1,995	6,367	4,987	12	1,592	6,591	245	49	90	384	13,342

Table 6.--Area of forest plantations by forest type, period planted, and working circle, Island of Hawaii, 1965

Working circle and forest type	Period of planting: 1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1965	Total
	Acres						
Hilo-Hamakua							
Robusta eucalyptus	39	970	2,930	70	--	--	4,009
Other eucalypts	11	263	743	11	--	35	1,063
Other hardwoods	--	94	510	--	--	4,390	4,994
Commercial conifers	--	--	295	3	2	--	300
Noncommercial types	77	1,148	163	10	--	--	1,398
Total	127	2,475	4,641	94	2	4,425	11,764
Kau							
Robusta eucalyptus	--	4	544	39	--	--	587
Other eucalypts	--	--	115	--	--	--	115
Other hardwoods	--	4	47	--	--	--	51
Commercial conifers	--	--	--	--	--	--	--
Noncommercial types	--	21	42	--	--	--	63
Total	--	29	748	39	--	--	816
Kona							
Robusta eucalyptus	--	3	200	--	--	--	203
Other eucalypts	--	6	145	--	--	69	220
Other hardwoods	--	--	141	--	--	1,321	1,462
Commercial conifers	--	--	17	41	--	--	58
Noncommercial types	--	19	432	62	--	--	513
Total	--	28	935	103	--	1,390	2,456
Kohala							
Robusta eucalyptus	--	--	134	7	--	--	141
Other eucalypts	--	--	27	2	--	--	29
Other hardwoods	--	59	25	--	--	--	84
Commercial conifers	--	13	13	--	--	--	26
Noncommercial types	--	--	210	--	--	--	210
Total	--	72	409	9	--	--	490
Total, all working circles	127	2,604	6,733	245	2	5,815	15,526

Table 7.--Volume of growing stock and sawtimber, by species, in planted sawtimber stands, Island of Hawaii, 1965

Species	Growing stock	Sawtimber
	Thousand cubic feet	Thousand board feet
Australian redcedar	23	88
Blackbutt eucalyptus	33	175
Brushbox	297	1,270
Deane eucalyptus	30	90
Eucalyptus spp.	1,802	7,287
Gray ironbark eucalyptus	18	96
Jhalna	98	224
Kinogum eucalyptus	286	1,282
Koa	3	14
Lemon eucalyptus	142	627
Maiden-gum eucalyptus	67	249
Molucca albizzia	221	1,154
Nepal alder	135	497
Norfolk-Island-pine	274	1,359
Ohia	132	394
Port-Orford-cedar	5	--
Redwood	20	94
Robusta eucalyptus	16,830	80,673
Saligna eucalyptus	2,415	13,895
Silk-oak	844	3,191
Sugi	619	1,181
Tallowwood eucalyptus	195	991
Tropical ash	464	1,331
Turpentine-tree	134	661
Western redcedar	20	20
Island total	25,107	116,843

Table 8.--Volume of growing stock and sawtimber in planted sawtimber stands by working circle, ownership class,[1] and species group, Island of Hawaii, 1965

(in thousands of feet)

Working circle and species group	State: Growing stock	State: Sawtimber	Hawaiian Homes: Growing stock	Hawaiian Homes: Sawtimber	Private: Growing stock	Private: Sawtimber	All ownerships: Growing stock	All ownerships: Sawtimber
	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]
Hilo-Hamakua								
Robusta eucalyptus	7,260	35,117	2,699	12,558	4,640	22,836	14,599	70,511
Saligna eucalyptus	1,538	9,212	467	2,706	276	1,421	2,281	13,339
Other eucalypts[3]	1,927	8,902	207	549	323	1,258	2,457	10,709
Silk-oak	479	1,873	9	--	--	--	488	1,873
Tropical ash	221	1,018	6	9	196	209	423	1,236
Other hardwoods[4]	252	923	47	23	44	149	343	1,095
Norfolk-Island-pine	--	--	--	--	186	899	186	899
Other conifers[5]	422	797	131	180	40	45	593	1,022
Total	12,099	57,842	3,566	16,025	5,705	26,817	21,370	100,684
Kau								
Robusta eucalyptus	755	3,444	--	--	569	2,664	1,324	6,108
Saligna eucalyptus	129	530	--	--	4	22	133	552
Other eucalypts[3]	28	121	--	--	18	80	46	201
Silk-oak	32	97	--	--	30	127	62	224
Other hardwoods[4]	3	4	--	--	--	--	3	4
Norfolk-Island-pine	2	--	--	--	--	--	2	--
Total	949	4,196	--	--	621	2,893	1,570	7,089
Kona								
Robusta eucalyptus	219	1,124	--	--	41	184	260	1,308
Other eucalypts[3]	325	1,024	--	--	25	105	350	1,129
Silk-oak	26	98	--	--	268	996	294	1,094
Tropical ash	37	86	--	--	4	9	41	95
Other hardwoods[4]	2	10	--	--	1	1	3	11
Commercial conifers[5]	39	165	--	--	20	66	59	231
Total	648	2,507	--	--	359	1,361	1,007	3,868
Kohála								
Robusta eucalyptus	116	378	60	261	471	2,107	647	2,746
Saligna eucalyptus	--	--	--	--	1	4	1	4
Other eucalypts[3]	10	36	--	--	141	653	151	689
Other hardwoods[4]	--	--	--	--	264	1,263	264	1,263
Norfolk-Island-pine	--	--	12	69	73	391	85	460
Other conifers[5]	--	--	10	32	2	8	12	40
Total	126	414	82	362	952	4,426	1,160	5,202
Total, all working circles	13,822	64,959	3,648	16,387	7,637	35,497	25,107	116,843

1/ Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand the ownership designation may be in error, although overall ownership statistics are probably not greatly affected by this kind of error.

2/ International 1/4-inch rule.

3/ Mainly *Eucalyptus* spp. but includes brushbox and turpentine-tree.

4/ Includes ohia, koa, Molucca albizzia, jhalna, Australian redcedar, and Nepal alder.

5/ Includes sugi, western redcedar, Port-Orford-cedar, baldcypress, and redwood.

Table 9.--Volume of cull trees in planted sawtimber stands by working circles and species groups, Island of Hawaii, 1965

Species group	Volume by working circle				
	Hilo-Hamakua	Kau	Kona	Kohala	All
	Thousand cubic feet				
Robusta eucalyptus	252	73	16	21	362
Saligna eucalyptus	9	4	--	--	13
Other commercial eucalypts1/	56	2	16	2	76
Silk-oak	8	3	19	--	30
Tropical ash	4	--	12	--	16
Other commercial hardwoods2/	36	1	5	1	43
Norfolk-Island-pine	1	--	--	1	2
Other commercial conifers3/	60	--	2	1	63
Noncommercial species4/	632	16	20	8	676
Total	1,058	99	90	34	1,281

1/ Mainly *Eucalyptus* spp. but includes brushbox and turpentine-tree.
2/ Includes ohia, koa, Molucca albizzia, jhalna, Australian redcedar, and Nepal alder.
3/ Includes sugi, western redcedar, Port-Orford-cedar, baldcypress, and redwood.
4/ Includes *Casuarina* spp., paperbark, bluegum eucalyptus, kukui, kopiko, *Ficus* spp., naio, jacaranda, and poinciana.

Table 10.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and tree diameter class, Island of Hawaii, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	80,673	--	3,603	7,368	10,993	12,958	39,386	5,916	449
Saligna eucalyptus	13,895	--	336	583	1,071	1,673	8,921	1,279	32
Other eucalypts[2]	12,728	--	903	1,786	2,162	2,402	4,853	606	16
Silk-oak	3,191	--	491	823	805	543	529	--	--
Tropical ash	1,331	--	56	124	202	228	540	181	--
Other hardwoods[3]	2,373	--	154	284	182	301	714	574	164
Norfolk-Island-pine	1,359	--	93	263	373	317	285	28	--
Other conifers[4]	1,293	--	280	345	243	191	234	--	--
Total	116,843	--	5,916	11,576	16,031	18,613	55,462	8,584	661
	Thousand cubic feet								
Robusta eucalyptus	16,830	893	1,289	1,884	2,309	2,464	6,955	967	69
Saligna eucalyptus	2,415	82	117	143	199	286	1,386	196	6
Other eucalypts[2]	3,004	300	334	457	457	462	884	103	7
Silk-oak	844	126	162	187	161	104	104	--	--
Tropical ash	464	37	159	32	43	47	109	37	--
Other hardwoods[3]	613	135	45	64	37	62	137	103	30
Norfolk-Island-pine	273	21	27	52	66	55	47	5	--
Other conifers[4]	664	324	114	92	54	37	43	--	--
Total	25,107	1,918	2,247	2,911	3,326	3,517	9,665	1,411	112

1/ International 1/4-inch rule.
2/ Mainly *Eucalyptus* spp. but includes brushbox and turpentine-tree.
3/ Includes ohia, koa, Molucca albizzia, jhalna, Australian redcedar, and Nepal alder.
4/ Includes sugi, western redcedar, Port-Orford-cedar, and redwood.

Table 11.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and tree diameter class in Hilo-Hamakua Working Circle, Island of Hawaii, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	70,511	--	3,092	5,884	9,288	11,071	35,357	5,377	442
Saligna eucalyptus	13,339	--	317	558	1,051	1,639	8,560	1,182	32
Other eucalypts[2]	10,709	--	716	1,414	1,856	2,023	4,112	579	9
Silk-oak	1,873	--	219	505	483	333	333	--	--
Tropical ash	1,236	--	40	105	176	220	514	181	--
Other hardwoods[3]	1,095	--	107	198	84	210	399	78	19
Norfolk-Island-pine	899	--	70	198	292	280	59	--	--
Other conifers[4]	1,022	--	260	310	197	134	121	--	--
Total	100,684	--	4,821	9,172	13,427	15,910	49,455	7,397	502
	Thousand cubic feet								
Robusta eucalyptus	14,599	788	1,099	1,492	1,944	2,102	6,231	875	68
Saligna eucalyptus	2,281	64	105	132	194	277	1,324	179	6
Other eucalypts[2]	2,457	237	253	354	389	383	736	99	6
Silk-oak	488	70	71	118	98	65	66	--	--
Tropical ash	423	26	152	26	35	45	102	37	--
Other hardwoods[3]	343	107	34	45	17	44	78	14	4
Norfolk-Island-pine	186	15	20	40	52	49	10	--	--
Other conifers[4]	593	319	103	82	43	25	21	--	--
Total	21,370	1,626	1,837	2,289	2,772	2,990	8,568	1,204	84

1/ International 1/4-inch rule.
2/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
3/ Includes ohia, koa, Molucca albizzia, jhalna, Australian redcedar, and Nepal alder.
4/ Includes sugi, western redcedar, Port-Orford-cedar, and redwood.

Table 12.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and tree diameter class in Kau Working Circle, Island of Hawaii, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	6,108	--	277	787	936	1,265	2,474	369	--
Saligna eucalyptus	552	--	19	25	20	32	359	97	--
Other eucalypts[2]	201	--	19	26	10	48	96	2	--
Silk-oak	224	--	32	24	28	78	62	--	--
Other hardwoods[3]	4	--	--	4	--	--	--	--	--
Norfolk-Island-pine	--	--	--	--	--	--	--	--	--
Total	7,089	--	347	866	994	1,423	2,991	468	--
	Thousand cubic feet								
Robusta eucalyptus	1,324	60	103	213	200	243	443	62	--
Saligna eucalyptus	133	18	12	11	5	8	62	17	--
Other eucalypts[2]	46	1	9	6	3	9	18	--	--
Silk-oak	62	13	10	6	6	15	12	--	--
Other hardwoods[3]	3	1	--	2	--	--	--	--	--
Norfolk-Island-pine	2	2	--	--	--	--	--	--	--
Total	1,570	95	134	238	214	275	535	79	--

1/ International 1/4-inch rule.
2/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
3/ Includes ohia and Australian redcedar.

Table 13.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and tree diameter class in Kona Working Circle, Island of Hawaii, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	1,308	--	29	118	164	124	748	125	--
Other eucalypts[2]	1,129	--	138	304	256	267	164	--	--
Silk-oak	1,094	--	240	294	294	132	134	--	--
Tropical ash	95	--	16	19	26	8	26	--	--
Other hardwoods[3]	11	--	--	--	--	--	9	--	2
Commercial conifers[4]	231	--	18	29	39	48	97	--	--
Total	3,868	--	441	764	779	579	1,178	125	2
	Thousand cubic feet								
Robusta eucalyptus	260	1	10	32	37	23	136	21	--
Other eucalypts[2]	350	57	60	85	57	58	33	--	--
Silk-oak	294	43	81	63	57	24	26	--	--
Tropical ash	41	11	7	6	8	2	7	--	--
Other hardwoods[3]	3	--	--	--	--	--	3	--	--
Commercial conifers[4]	59	4	9	8	9	10	19	--	--
Total	1,007	116	167	194	168	117	224	21	--

1/ International 1/4-inch rule.
2/ All commercial *Eucalyptus* spp. except *Eucalyptus robusta*.
3/ Includes ohia and koa.
4/ Includes sugi, western redcedar, Port-Orford-cedar, and redwood.

Table 14.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and tree diameter class in Kohala Working Circle, Island of Hawaii, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	2,746	--	205	579	605	498	807	45	7
Saligna eucalyptus	4	--	--	--	--	2	2	--	--
Other eucalypts[2]	689	--	30	42	40	64	481	25	7
Other hardwoods[3]	1,263	--	47	82	98	91	306	496	143
Norfolk-Island-pine	460	--	23	65	81	37	226	28	--
Other conifers[4]	40	--	2	6	7	9	16	--	--
Total	5,202	--	307	774	831	701	1,838	594	157
	Thousand cubic feet								
Robusta eucalyptus	647	44	77	147	128	96	145	9	1
Saligna eucalyptus	1	--	--	--	--	1	--	--	--
Other eucalypts[2]	151	5	12	12	8	12	97	4	1
Other hardwoods[3]	264	27	11	17	20	18	56	89	26
Norfolk-Island-pine	85	4	7	12	14	6	37	5	--
Other conifers[4]	12	1	2	2	2	2	3	--	--
Total	1,160	81	109	190	172	135	338	107	28

1/ International 1/4-inch rule.
2/ Mainly Eucalyptus spp. but includes brushbox.
3/ Includes ohia, Molucca albizzia, and jhalna.
4/ Includes sugi and other commercial conifers.

Table 15.-Sawtimber volume in planted sawtimber stands in Hilo-Hamakua Working Circle by ownership class, species group, and log grade,1/ Island of Hawaii, 1965

Ownership class and species group	All grades	Factory lumber logs: Grade 1	Factory lumber logs: Grade 2	Factory lumber logs: Grade 3	Tie and timber logs: Grade 4	Softwood species2/
	Thousand board feet3/					
State						
Robusta eucalyptus	35,117	8,056	8,025	8,011	11,025	--
Saligna eucalyptus	9,212	4,406	1,981	1,551	1,274	--
Other eucalypts4/	8,902	1,842	2,329	2,197	2,534	--
Silk-oak	1,873	26	400	591	856	--
Tropical ash	1,018	167	277	359	215	--
Other hardwoods5/	923	73	147	202	501	--
Commercial conifers6/	797	--	--	--	--	797
Total	57,842	14,570	13,159	12,911	16,405	797
Hawaiian Homes						
Robusta eucalyptus	12,558	2,423	2,877	3,053	4,205	--
Saligna eucalyptus	2,706	1,327	640	490	249	--
Other eucalypts4/	549	--	112	152	285	--
Tropical ash	9	--	--	3	6	--
Other hardwoods5/	23	--	11	9	3	--
Commercial conifers6/	180	--	--	--	--	180
Total	16,025	3,750	3,640	3,707	4,748	180
Private						
Robusta eucalyptus	22,836	6,827	5,108	4,564	6,337	--
Saligna eucalyptus	1,421	454	386	308	273	--
Other eucalypts4/	1,258	76	247	407	528	--
Tropical ash	209	29	39	69	72	--
Other hardwoods5/	149	10	25	20	94	--
Norfolk-Island-pine	899	--	--	--	--	899
Other conifers6/	45	--	--	--	--	45
Total	26,817	7,396	5,805	5,368	7,304	944
All Ownerships						
Robusta eucalyptus	70,511	17,306	16,010	15,628	21,567	--
Saligna eucalyptus	13,339	6,187	3,007	2,349	1,796	--
Other eucalypts4/	10,709	1,918	2,688	2,756	3,347	--
Silk-oak	1,873	26	400	591	856	--
Tropical ash	1,236	196	316	431	293	--
Other hardwoods5/	1,095	83	183	231	598	--
Norfolk-Island-pine	899	--	--	--	--	899
Other conifers6/	1,022	--	--	--	--	1,022
Total	100,684	25,716	22,604	21,986	28,457	1,921

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ Commercial conifer species are not log-graded.
3/ International 1/4-inch rule.
4/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
5/ Includes ohia, koa, Molucca albizzia, jhalna, Australian redcedar, and Nepal alder.
6/ Includes sugi, western redcedar, Port-Orford-cedar, and redwood.

Table 16.--Sawtimber volume in planted sawtimber stands in Kau Working Circle by ownership class, species group, and log grade,[1] Island of Hawaii, 1965

Ownership class and species group[2]	All grades	Factory lumber logs: Grade 1	Factory lumber logs: Grade 2	Factory lumber logs: Grade 3	Tie and timber logs: Grade 4
	Thousand board feet[3]				
State					
Robusta eucalyptus	3,444	571	516	955	1,402
Saligna eucalyptus	530	203	173	76	78
Other eucalypts[4]	121	15	17	40	49
Silk-oak	97	--	16	41	40
Other hardwoods[5]	4	--	--	4	--
Total	4,196	789	722	1,116	1,569
Hawaiian Homes	--	--	--	--	--
Private					
Robusta eucalyptus	2,664	627	543	711	783
Saligna eucalyptus	22	10	8	--	4
Other eucalypts[4]	80	33	9	19	19
Silk-oak	127	6	43	53	25
Total	2,893	676	603	783	831
All Ownerships					
Robusta eucalyptus	6,108	1,198	1,059	1,666	2,185
Saligna eucalyptus	552	213	181	76	82
Other eucalypts[4]	201	48	26	59	68
Silk-oak	224	6	59	94	65
Other hardwoods[5]	4	--	--	4	--
Total	7,089	1,465	1,325	1,899	2,400

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ No conifer sawtimber tallied in Kau Working Circle.
3/ International 1/4-inch rule.
4/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
5/ Includes ohia and Australian redcedar.

Table 17.--Sawtimber volume in planted sawtimber stands in Kona Working Circle by ownership class, species group, and log grade,[1] Island of Hawaii, 1965

Ownership class and species group	All grades	Factory lumber logs: Grade 1	Factory lumber logs: Grade 2	Factory lumber logs: Grade 3	Tie and timber logs: Grade 4	Softwood species[2]
	Thousand board feet[3]					
State						
Robusta eucalyptus	1,124	232	238	245	409	--
Other eucalypts[4]	1,024	--	15	184	825	--
Silk-oak	98	--	40	22	36	--
Tropical ash	86	--	31	21	34	--
Other hardwoods[5]	10	2	--	8	--	--
Commercial conifers[6]	165	--	--	--	--	165
Total	2,507	234	324	480	1,304	165
Hawaiian Homes	--	--	--	--	--	--
Private						
Robusta eucalyptus	184	2	28	24	130	--
Other eucalypts[4]	105	6	12	32	55	--
Silk-oak	996	--	59	386	551	--
Tropical ash	9	1	2	2	4	--
Other hardwoods[5]	1	--	--	--	1	--
Commercial conifers[6]	66	--	--	--	--	66
Total	1,361	9	101	444	741	66
All Ownerships						
Robusta eucalyptus	1,308	234	266	269	539	--
Other eucalypts[4]	1,129	6	27	216	880	--
Silk-oak	1,094	--	99	408	587	--
Tropical ash	95	1	33	23	38	--
Other hardwoods[5]	11	2	--	8	1	--
Commercial conifers[6]	231	--	--	--	--	231
Total	3,868	243	425	924	2,045	231

1/ Based on standard specifications for hardwood log grades for standard lumber.

2/ All commercial conifer species are not log graded.

3/ International 1/4-inch rule.

4/ All commercial *Eucalyptus* spp. except *Eucalyptus robusta*.

5/ Includes ohia and koa.

6/ Includes sugi, western redcedar, Port-Orford-cedar, and redwood.

Table 18.--Sawtimber volume in planted sawtimber stands in Kohala Working Circle by ownership class, species group, and log grade,[1] Island of Hawaii, 1965

Ownership class and species group	All grades	Factory lumber logs Grade 1	Grade 2	Grade 3	Tie and timber logs Grade 4	Softwood species[2]
	Thousand board feet[3]					
State						
Robusta eucalyptus	378	27	17	52	282	--
Other eucalypts[4]	36	3	5	9	19	--
Total	414	30	22	61	301	--
Hawaiian Homes						
Robusta eucalyptus	261	27	36	75	123	--
Norfolk-Island-pine	69	--	--	--	--	69
Other conifers[6]	32	--	--	--	--	32
Total	362	27	36	75	123	101
Private						
Robusta eucalyptus	2,107	147	285	547	1,128	--
Saligna eucalyptus	4	--	1	2	1	--
Other eucalypts[4]	653	121	169	150	213	--
Other hardwoods[5]	1,263	679	319	152	113	--
Norfolk-Island-pine	391	--	--	--	--	391
Other conifers[6]	8	--	--	--	--	8
Total	4,426	947	774	851	1,455	399
All Ownerships						
Robusta eucalyptus	2,746	201	338	674	1,533	--
Saligna eucalyptus	4	--	1	2	1	--
Other eucalypts[4]	689	124	174	159	232	--
Other hardwoods[5]	1,263	679	319	152	113	--
Norfolk-Island-pine	460	--	--	--	--	460
Other conifers[6]	40	--	--	--	--	40
Total	5,202	1,004	832	987	1,879	500

1/ Based on standard specifications for hardwood log grades for standard lumber.

2/ All commercial conifer species are not log graded.

3/ International 1/4-inch rule.

4/ Mainly *Eucalyptus* spp. but includes brushbox.

5/ Includes ohia, Molucca albizzia, and jhalna.

6/ Includes sugi and other commercial conifers.

Table 19.--Listing of individual stands and plantings with species type, ownership, area, and volume, Island of Hawaii, 1965

Stand no.	Species type	Owner 1/	Acres	Total stand volume
				Thousand board feet
8001	Robusta eucalyptus	223	119	1,007
8002	Ironwood	223	45	-- 2/
8003	Robusta eucalyptus	112	37	470
8004	" "	223	84	1,014
8005	" "	112	230	1,543
8006	Robusta eucalyptus	112	245	3,391
8007	" "	112	56	703
8008	" "	112	16	107
8009	" "	112	85	1,211
8010	" "	322	46	929
8011	Robusta eucalyptus	243	48	1,063
8012	" "	241	90	2,831
8013	" "	241	154	3,274
8014	" "	241	45	927
8015	" "	241	45	671
8016	Robusta eucalyptus	241	10	140
8017	" "	112	60	414
8018	" "	243	26	473
8019	" "	241	10	211
8020	" "	243	9	158
8021	Tropical ash	112	63	849
8022	Mixed eucalyptus	225	67	210
8023	Tropical ash	112	16	116
8024	Silk-oak	112	24	114
8025	Robusta eucalyptus	112	60	1,123

1/ Code numbers in this column identify landowners as State (112), lands under jurisdiction of Hawaiian Homes Commission (111), and private owners (all other numbers).

Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand the ownership designation may be in error, although overall ownership statistics are probably not greatly affected by this kind of error.

2/ -- indicates noncommercial plantation type throughout table.

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8026	Robusta eucalyptus	112	50	2,010
8027	Lemon eucalyptus	225	10	114
8028	Ironwood	225	3	--
8029	Norfolk-Island-pine	225	33	899
8030	Robusta eucalyptus	225	34	647
8031	Ironwood	225	6	--
8032	Robusta eucalyptus	225	51	1,815
8033	Tropical ash	225	15	29
8034	" "	248	11	167
8035	Robusta eucalyptus	112	42	417
8036	Mixed eucalyptus	112	23	112
8037	" "	112	10	13
8038	Robusta eucalyptus	111	210	5,402
8039	Saligna eucalyptus	111	16	555
8040	Robusta eucalyptus	111	19	219
8041	Mixed eucalyptus	112	111	2,566
8042	Saligna eucalyptus	112	21	780
8043	Robusta eucalyptus	112	214	3,937
8044	" "	111	200	3,377
8045	" "	111	12	305
8046	Robusta eucalyptus	111	32	714
8047	" "	111	28	361
8048	" "	111	116	1,929
8049	Mixed eucalyptus	111	140	1,975
8050	Paper-bark	111	4	--
8051	Tropical ash	111	5	9
8052	Brushbox	111	7	8
8053	Mixed eucalyptus	111	15	16
8054	Monterey cypress	111	12	--
8055	Robusta eucalyptus	248	3	63
8056	Mixed eucalyptus	112	67	657
8057	Brushbox	112	20	426
8058	Robusta eucalyptus	112	60	1,281
8059	Mixed eucalyptus	112	14	118
8060	Robusta eucalyptus	112	18	434

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8061	Robusta eucalyptus	225	18	483
8062	" "	324	11	343
8063	" "	324	3	93
8064	" "	323	45	843
8065	" "	225	47	642
8066	Lemon eucalyptus	225	11	14
8067	Mixed eucalyptus	112	83	1,686
8068	Silk-oak	112	60	981
8069	Mixed eucalyptus	112	36	754
8070	Saligna eucalyptus	112	13	490
8071	Mixed eucalyptus	112	39	1,309
8072	Mixed species	112	58	910
8073	" "	112	8	274
8074	Tallowwood eucalyptus	112	8	350
8075	Robusta eucalyptus	112	24	604
8076	Silk-oak	112	36	622
8077	Mixed species	112	69	1,705
8078	Bluegum eucalyptus	112	230	--
8079	" "	112	140	--
8080	" "	112	26	--
8081	Bluegum eucalyptus	112	413	--
8082	" "	112	72	--
8083	Robusta eucalyptus	217	4	137
8084	Mixed eucalyptus	217	27	482
8085	Bluegum eucalyptus	112	40	--
8086	Bluegum eucalyptus	112	120	--
8087	" "	303	50	--
8088	" "	303	60	--
8089	" "	217	3	--
8090	" "	217	3	--
8091	Bluegum eucalyptus	217	4	--
8092	" "	217	38	--
8093	Robusta eucalyptus	112	28	711
8094	" "	112	51	1,800
8095	Mixed eucalyptus	112	23	309

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8096	Robusta eucalyptus	112	15	388
8097	Mixed eucalyptus	112	12	463
8098	Saligna eucalyptus	112	21	1,012
8099	Mixed eucalyptus	217	6	123
8100	Robusta eucalyptus	242	3	38
8101	Saligna eucalyptus	242	3	62
8102	Mixed eucalyptus	242	3	61
8103	" "	248	9	48
8104	" "	248	11	197
8105	" "	248	10	81
8106	Mixed eucalyptus	248	10	65
8107	Robusta eucalyptus	248	59	991
8108	" "	248	83	324
8109	Saligna eucalyptus	111	11	57
8110	Robusta eucalyptus	112	89	2,118
8111	Paper-bark	248	7	--
8112	Sugi	248	3	*3/
8113	Paper-bark	248	3	--
8114	Sugi	248	5	4
8115	Robusta eucalyptus	248	10	254
8116	Robusta eucalyptus	112	58	460
8117	" "	204	26	249
8118	Bluegum eucalyptus	204	21	--
8119	Mixed species	112	23	222
8120	" "	112	65	424
8121	Sugi	112	110	620
8122	Robusta eucalyptus	112	88	2,157
8123	" "	112	102	1,837
8124	" "	223	8	207
8125	" "	223	78	1,316
8126	Robusta eucalyptus	112	34	450
8127	" "	112	6	29
8128	Sugi	112	86	39
8129	Robusta eucalyptus	248	5	5
8130	Mixed eucalyptus	112	2	41

3/ * indicates poletimber or seedling and sapling stands throughout table.

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8131	Robusta eucalyptus	112	138	2,208
8132	" "	241	5	43
8133	Paper-bark	241	8	--
8134	Robusta eucalyptus	112	40	603
8135	Nepal alder	112	7	64
8136	Robusta eucalyptus	112	9	30
8137	Silk-oak	112	11	94
8138	Robusta eucalyptus	112	70	412
8139	" "	223	22	536
8140	Nepal alder	112	6	58
8141	Nepal alder	112	16	175
8142	Robusta eucalyptus	243	5	61
8143	" "	112	40	939
8144	" "	243	8	237
8145	Saligna eucalyptus	243	5	62
8146	Robusta eucalyptus	112	9	717
8147	" "	241	7	201
8148	Sugi	243	22	9
8149	Robusta eucalyptus	112	27	539
8150	Paper-bark	112	8	--
8151	Robusta eucalyptus	112	26	149
8152	Sugi	111	3	59
8153	Paper-bark	243	7	--
8154	Robusta eucalyptus	111	67	912
8155	Sugi	111	36	129
8156	Paper-bark	241	7	--
8157	Robusta eucalyptus	112	3	14
8158	Nepal alder	112	8	116
8159	" "	112	11	46
8160	" "	112	2	19
8161	Nepal alder	112	2	18
8162	Mixed eucalyptus	112	18	693
8163	Saligna eucalyptus	225	3	41
8164	Mixed species	225	4	63
8165	" "	112	41	173

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8166	Tropical ash	112	7	99
8167	Robusta eucalyptus	112	13	375
8168	Tallowwood eucalyptus	112	7	231
8169	Mixed eucalyptus	112	31	341
8170	Saligna eucalyptus	217	17	905
8171	Mixed eucalyptus	112	10	159
8172	Silk-oak	112	5	50
8173	Robusta eucalyptus	217	9	227
8174	Mixed eucalyptus	112	9	122
8175	Ironwood	112	22	--
8176	Bluegum eucalyptus	248	5	--
8177	Saligna eucalyptus	112	15	632
8178	Mixed eucalyptus	112	50	980
8179	Ironwood	112	18	--
8180	Saligna eucalyptus	112	21	1,389
8181	Norfolk-Island-pine	111	2	*
8182	Tropical ash	248	4	56
8183	Robusta eucalyptus	112	23	471
8184	Mixed eucalyptus	112	8	228
8185	Robusta eucalyptus	248	29	723
8186	Tallowwood eucalyptus	112	2	88
8187	Ironwood	112	23	--
8201	Saligna eucalyptus	112	45	322
8202	Mixed eucalyptus	112	70	752
8203	Silk-oak	112	6	*
8204	Robusta eucalyptus	112	33	247
8205	" "	326	4	10
8206	" "	226	10	115
8207	" "	226	3	34
8208	Bluegum eucalyptus	226	7	--
8209	Ironwood	226	11	--
8210	Silk-oak	219	2	17
8211	Robusta eucalyptus	219	69	557
8212	" "	226	9	32
8213	" "	112	7	138

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8214	Robusta eucalyptus	112	11	87
8215	Ironwood	112	31	--
8216	Robusta eucalyptus	112	33	303
8217	" "	112	18	350
8218	Bluegum eucalyptus	219	3	--
8219	Robusta eucalyptus	112	69	899
8220	Bluegum eucalyptus	112	4	--
8221	Robusta eucalyptus	112	30	498
8222	" "	112	28	269
8223	" "	112	15	47
8224	Robusta eucalyptus	112	31	82
8225	" "	112	9	123
8226	Silk-oak	219	4	19
8227	" "	112	4	34
8228	Mixed species	219	27	118
8229	Bluegum eucalyptus	326	4	--
8230	Silk-oak	219	4	34
8231	Robusta eucalyptus	219	27	157
8232	" "	219	34	888
8233	" "	219	6	52
8234	Robusta eucalyptus	219	9	163
8235	" "	219	9	323
8236	Bluegum eucalyptus	112	3	--
8237	Robusta eucalyptus	219	115	303
8238	" "	219	3	26
8239	Robusta eucalyptus	219	5	56
8240	Silk-oak	112	4	34
8301	Mixed eucalyptus	248	9	--
8302	" "	248	8	--
8303	Saligna eucalyptus	248	11	--
8304	Mixed eucalyptus	248	16	--
8305	" "	248	9	--
8306	" "	248	42	--
8307	" "	248	3	--
8308	" "	248	60	--

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8309	Mixed eucalyptus	248	58	--
8310	" "	248	60	--
8311	" "	248	9	--
8312	" "	248	6	--
8313	" "	248	2	--
8314	Mixed eucalyptus	248	3	--
8315	" "	248	2	--
8316	Robusta eucalyptus	248	6	--
8317	Mixed eucalyptus	248	50	--
8318	" "	248	12	--
8319	Mixed eucalyptus	248	12	--
8320	" "	248	13	--
8321	" "	248	11	--
8322	" "	112	2	--
8323	" "	248	2	--
8324	Mixed eucalyptus	248	2	--
8325	" "	248	10	--
8326	" "	248	14	--
8327	" "	248	9	--
8328	" "	248	11	--
8329	Mixed eucalyptus	248	3	--
8330	" "	248	11	--
8331	" "	248	10	--
8332	" conifers	112	41	*
8333	" eucalyptus	112	103	863
8334	Mixed eucalyptus	112	40	161
8335	Robusta eucalyptus	112	3	22
8336	Robusta eucalyptus	112	3	25
8337	Mixed eucalyptus	211	4	30
8338	Mixed species	211	3	9
8339	Mixed eucalyptus	213	2	15
8340	Robusta eucalyptus	213	3	23
8341	Sugi	213	3	22
8342	"	213	6	44
8343	Tropical ash	112	25	73

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8344	Robusta eucalyptus	112	148	1,108
8345	Silk-oak	249	91	986
8346	Silk-oak	112	22	98
8347	Robusta eucalyptus	204	46	216
8348	Mixed eucalyptus	211	2	15
8349	Mixed eucalyptus	248	2	--
8350	" "	111	35	--
8351	Sugi	112	8	158
8401	Lemon eucalyptus	325	6	212
8402	Norfolk-Island-pine	325	5	97
8403	Jhalna	231	6	97
8404	Ironwood	231	5	--
8405	"	231	7	--
8406	"	231	3	--
8407	"	231	5	--
8408	Ironwood	231	3	--
8409	Robusta eucalyptus	231	4	89
8410	Ironwood	231	5	--
8411	"	231	6	--
8412	Robusta eucalyptus	231	16	319
8413	Mixed eucalyptus	325	6	187
8414	Ironwood	325	33	--
8415	"	325	15	--
8416	Mixed eucalyptus	231	3	60
8417	Ironwood	231	4	--
8418	Ironwood	231	4	--
8419	"	231	4	--
8420	"	231	4	--
8421	"	231	3	--
8422	"	231	15	--
8423	Ironwood	231	10	--
8424	Norfolk-Island-pine	231	13	292
8425	Robusta eucalyptus	231	7	64
8426	" "	231	10	246
8427	" "	231	8	257

Table 19, continued

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
8428	Robusta eucalyptus	231	5	115
8429	" "	231	4	80
8430	Mixed eucalyptus	231	2	40
8431	Robusta eucalyptus	231	5	90
8432	Ironwood	231	20	--
8433	Ironwood	231	28	--
8434	Jhalna	231	3	49
8435	Molucca albizzia	231	32	218
8436	" "	231	27	761
8437	Robusta eucalyptus	231	20	619
8438	Robusta eucalyptus	231	5	111
8439	" "	231	3	93
8440	Mixed eucalyptus	231	4	72
8441	Ironwood	227	4	--
8442	Paper-bark	248	11	--
8443	Tropical ash	248	9	*
8444	Robusta eucalyptus	112	33	378
8445	" "	111	5	71
8446	" "	111	3	60
8447	" "	111	5	72
8448	Sugi	111	5	32
8449	Ironwood	111	16	--
8450	Robusta eucalyptus	111	5	60
8451	Mixed eucalyptus	112	4	36
8452	" "	231	4	46
8453	Jhalna	231	4	65
8454	Robusta eucalyptus	231	3	66
8455	Norfolk-Island-pine	111	3	64
8456	Molucca albizzia	231	3	84
8457	Paper-bark	248	5	--
	Total Forest Plantation (prior to 1957)		9,711	116,843

Table 19, continued

Species type	Owner	Acres	Total stand volume
Waiakea area[4/]			
Australian redcedar	112	1,859	*
Tropical ash	112	932	*
Australian redcedar-tropical ash	112	1,500	*
Australian redcedar-Spanish cedar	112	25	*
Mixed hardwood spp.	112	74	*
Eucalyptus spp.	112	35	*
Total Waiakea		4,425	
Honaunau area[4/]			
Australian redcedar	204	868	*
Tropical ash	204	387	*
Spanish cedar	204	66	*
Eucalyptus-Australian redcedar	204	60	*
Eucalyptus spp.	204	9	*
Total Honaunau		1,390	
Total reforestation area		5,815	
Total all forest plantations		15,526	

4/ Areas reforested between 1957-1965; no stand numbers assigned.

Table 20.--Identity of individual plantation stands in the groups shown on the map "Forest Plantations on the Island of Hawaii--1965"[1/]

Group stand no.	Individual stand no.	Group stand no.	Individual stand no.
1	8126, 49-51	31	8154-55, 63-64
2	8134, 37-38	32	8022-25, 33
3	8001-02, 8124-25	33	8026-32
4	8007, 8122-23, 36, 67	34	8110
5	8005-06	35	8135, 40-41, 59-61
6	8004, 8139	36	8107-09, 58, 81, 85
7	8014-16	37	8127-30, 57
8	8012-13, 19-20, 8153, 56	38	8442-50, 55, 57
9	8008-11, 17-18, 8142-48, 83	39	8441
10	8131-33	40	8403, 09, 33-40, 52-54, 56
11	8165	41	8424-31, 51
12	8021	42	8401-02, 10-23, 32
13	8121	43	8404-08
14	8085-86, 88, 8116-20	44	8301-03, 12-16, 30-31, 50
15	8093-98, 8162, 71-72, 74-75, 77-80	45	8304-11, 22
		46	8317-21, 23-29, 49
16	8170, 73	47	8346
17	8168-69	48	8345
18	8083-84, 99	49	8344
19	8087, 89-92	50	8322-38, 43, 47-48, 51
20	8078-82		
		51	8339-42
21	8103-06, 8111-12, 76	52	8201-06, 29
22	8100-02	53	8206-09, 12
23	8067-77, 8166, 86	54	8213-17, 19, 21-25
24	8044-49, 8113-15	55	8210, 26, 28
25	8056-61, 8184		
		56	8218, 32-35
26	8062-66	57	8211, 30-31, 37-39
27	8003, 35-37, 50-53	58	8220, 27, 36, 40
28	8034, 54-55, 8152, 82		
29	8041-43, 8187		
30	8038-40		

1/ Unnumbered stands on the map are identified by symbols as follows:

WRP--Waiakea reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

HRP--Honaunau reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

WA--Waiakea Arboretum.

HExP--Honaunau experimental planting.

GPO 973-060

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 4 1966

Commercial Forest Area and Timber Volume in California, 1963

Daniel D. Oswald and E. M. Hornibrook

Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

Contents

The Authors

DANIEL D. OSWALD is assigned to the Forest Survey staff, with headquarters in Berkeley. He holds a bachelor's degree in forestry from the University of California (1958) and also has done graduate work there. After graduation he served in the Navy, and joined the Forest Service in 1962. E. M. HORNIBROOK was in charge of the Station's Forest Survey until his retirement in 1965. He came to the Berkeley staff in 1949 after assignments at the Rocky Mountain and Southwestern Experiment Stations and on the National Forests in Washington, Arizona, and New Mexico. He is a 1928 forestry graduate of Oregon State University.

ACKNOWLEDGMENTS

The authors and the Station are grateful for the cooperation and information provided by the Division of Timber Management, California Region, U.S. Forest Service; California Division of Forestry; Bureau of Land Management and Bureau of Indian Affairs, both of the U.S. Department of Interior; and local public agencies and various private firms and individuals. Acknowledgment also is made of the help of colleagues on the Station's Forest Survey staff and data processing section.

This report summarizes the findings of a re-inventory of California's forest resources. Field work for the inventory was completed in 1962, and data were compiled as of January 1, 1963.

The Forest Service, U.S. Department of Agriculture, conducts continuing surveys of the forest resources of the United States, to provide periodic estimates of the nation's timber resources for use in policy planning and program formulation. The forest survey is conducted on a regional basis by the experiment stations of the Forest Service. The Pacific Southwest Forest and Range Experiment Station was responsible for this survey in California.

The initial survey of California was completed in 1952, and its findings were reported in the publication "Forest Statistics for California."[1] Much of the information for 1963 has been published in "Timber Trends in the United States"[2]; it is consolidated here for the convenience of California planners.

Users of the data in this report are cautioned to read carefully the definitions of the terms used, and the statements pertaining to reliability of the estimates, given in the appendix.

Findings for 1963

California's forests support a multiplicity of uses. Their existence, in one way or another, affects every person in the State, and many persons in other parts of the country. This report, however, is primarily concerned with California's forests as a timber resource.

Commercial Forest Area

About 41 percent of California's forested area grows or could grow commercial crops of timber, and is not set aside for other uses. This 17.4-million-acre area is California's commercial forest land[3] (table 1).[4] The remainder of the forest land area--more than 25 million acres--consists of unproductive areas, where adverse site conditions preclude timber management, and of productive but reserved land in parks and wilderness areas.

Most of the commercial forest land lies in the northern half of the State, chiefly in the north coast and northern counties, and along the Sierra Nevada. Some is in scattered locations in the mountains of southern California.

---

[1]U.S. Forest Serv. Calif. Forest & Range Exp. Sta. Forest Survey Rel. 25, 63 pp., illus. 1954.

[2]Forest Serv. U.S. Dep. Agr. Forest Resource Rep. 17, 235 pp., illus. 1965.

[3]See the appendix for definitions of terms used in this report.

[4]All tables in this report are included in the appendix.

Commercial Forest Land Ownership

In California, ownership of commercial forest land is almost equally divided between public agencies and private firms and individuals. Nearly 50 percent of the commercial forest land--8.6 million acres--is administered by the U.S. Forest Service. An additional 3 percent--0.6 million acres--is in other public ownerships. The remaining 47 percent--8.2 million acres--is in private holdings (table 2). Forest industries own 37 percent of the privately held commercial forest land.

Stand-Size Classes

Seventy-four percent of California's commercial forest land is stocked with sawtimber size stands of timber. Old-growth sawtimber stands, where 50 percent or more of the net live timber volume is in old-growth trees, occupy 8.7 million acres. These old-growth stands occupy half of the State's commercial forest area, and should continue to be important in California's timber supply out-look. Young-growth sawtimber stands occupy 4.1 million acres. Of the remaining acreage, 0.8 million acres are stocked with poletimber, seedlings, and saplings, and 3.8 million acres are classified as less than 10 percent stocked (table 3).

Stocking

Nearly a third of California's commercial forest land area is occupied by well stocked stands. About a third is medium stocked, and the remainder is either poorly stocked or nonstocked. Sawtimber stands account for 94 percent of the stocked stands, and pole stands make up most of the remaining 6 percent (table 4).

Major Forest Types

All pine types combined account for one-half of the State's commercial forest land area (table 5). And more than half of the pine type acreage is in public ownership. The most important pine types and their share of the commercial forest land are: ponderosa and Jeffrey pine, 35 percent; sugar pine, 13 percent.

Douglas-fir type, mostly in the northern coastal counties, occupies 25 percent of the commercial forest land--about equally divided between public and private ownerships. The true firs (fir-spruce type) occupy 16 percent of the State's commercial forest area--about two-thirds publicly owned, and one-third privately owned. The redwood type, occupying 9 percent of the State's commercial forest land total, is confined to a narrow belt that coincides with the fog belt along the northern California coastline. Most of it is privately owned.

Yield Classes

Yield classes are measures of the potential yield of a forest area in terms of cubic feet or wood per acre per year. One-third of the State's commercial forest land has a high yield potential. Only 4 percent of the commercial forest area is incapable of yielding more than 50 cubic feet of wood per acre per year (table 6).

Timber Volume

In 1963, California's commercial forests held 304 billion board feet (International 1/4-inch log rule) of live merchantable sawtimber. This is the net volume of all merchantable softwoods and hardwoods, 11.0 inches and larger in diameter, regardless of current availability for use. This volume includes timber currently inaccessible or located in scattered patches each of at least 1 acre, timber now unmarketable because of size or species, and timber in areas where recreation or watershed considerations preclude harvest operations at the present time (table 8).

More than half (53 percent) of this volume is on National Forest lands, 43 percent on private lands, and the remaining 4 percent in other public ownerships.

Softwood species comprise 99.5 percent of the 304 billion board feet of sawtimber volume (table 8). One-third of the live sawtimber volume in California is Douglas-fir. True firs (white fir, California red fir, and grand fir) account for one-fourth of the total; ponderosa and Jeffrey pine, one-fifth; redwood, one-tenth (table 9).

Almost 40 percent of the total volume of standing sawtimber is in trees 39 inches or larger in diameter (table 10). This finding reflects the large amount of old-growth sawtimber that remains in California. Only 10 percent of the volume is small sawtimber (11.0 to 18.9 inches in diameter).

Growth and Mortality

For the decade 1953-62, average annual net growth on California's 17.4 million acres of commercial forest land was 3.5 billion board feet or 201 board feet per acre per year (table 11). Douglas-fir and the true firs each accounted for 27 percent of the net growth; ponderosa and Jeffrey pine combined accounted for 19 percent; redwood, 14 percent.

An average of 2.25 billion board feet of sawtimber volume was lost annually to fire, insects, disease, windthrow, and other destructive agents of natural mortality during the 10-year period (table 12). The average annual net volume per acre mortality for the period was 129 board feet per acre.

Annual Cut

More than 99 percent of the sawtimber cut from commercial forests in California in 1962 was softwood. Of the 5.7 billion board feet removed from growing stock in logging, all but 461 million board feet were used for wood products; the remainder was left as logging residues (table 13). Douglas-fir accounted for 41 percent of the cut; redwood, ponderosa and Jeffrey pine and the true firs, accounted for 18, 15, and 15 percent, respectively (table 14). Hardwoods accounted for less than 1 percent of the timber cut in 1962. They contributed about the same percentage of the total inventory and total growth.

The annual cut figures presented in this report differ slightly from those reported in the Forest Service report "Timber Trends in the United States,"[5] which were based upon Bureau of Census production reports.

---

[5] See footnote 2.

Appendix

Tables

Table 1.--*Land area, by major classes of land, California, 1963*

Class of land	Area
	Thousand acres
Forest:	
Commercial	17,391
Noncommercial	
Productive--reserved	1,194
Unproductive	23,956
Total forest	42,541
Non-forest	[1] 57,666
Total, all classes	100,207

[1]Includes 83,000 acres of water according to Survey standards of area classification but defined by the Bureau of Census as land.

Table 2.--*Commercial forest land area, by ownership classes, California, 1963*[1]

Ownership class	Area
	Thousand acres
Federal:	
National Forest	8,656
Bureau of Land Management	326
Indian	110
Other	40
Total	9,132
State	91
County and municipal	8
Total	99
Private:	
Forest industry	2,987
Farm	1,609
Other private	3,564
Total	8,160
Total, all ownership	17,391

[1]Ownership breakdowns revised based upon information unavailable for "Timber Trends in the United States." U.S. Dep. Agr., Forest Serv. Forest Resource Rep. 17. 1965.

Table 3. --*Commercial forest land area, by stand-size classes, California, 1963*

Stand-size class	Area
	Thousand acres
Sawtimber stands:	
Old growth	8,703
Young growth	4,095
Total	12,798
Poletimber stands	763
Sapling and seedling stands	76
Nonstocked areas	3,754
Total, all classes	17,391

Table 4.--*Commercial forest land area, by stocking classes of growing-stock trees and by stand-size classes, California, 1963*

Stocking class	All stands	Saw-timber stands	Pole-timber stands	Sapling and seed-ling stands	Non-stocked stands
	Thousand acres				
Well-stocked	4,980	4,810	169	1	--
Medium-stocked	5,290	5,006	281	3	--
Poorly-stocked	3,367	2,982	313	72	--
Non-stocked	3,754	--	--	--	3,754
Total, all classes	17,391	12,798	763	76	3,754

Table 5.--*Commercial forest land area, by major forest types*[1] *and ownership groups, California, 1963*

Type	All ownerships	Public ownerships	Private ownerships
	Thousand acres		
Softwoods:			
Douglas-fir	4,402	2,315	2,087
Hemlock--sitka spruce	6	1	5
Redwood	1,586	130	1,456
Ponderosa pine	6,069	3,517	2,552
White pine (sugar pine)	2,254	1,352	902
Lodgepole pine	301	227	74
Fir--spruce	2,753	1,791	962
Hardwoods	20	14	6
Total, all types	17,391	9,347	8,044

[1]The forest types presented in this table conform with standard types as defined by Forest Survey.

Table 6.--*Commercial forest land area, by yield class, California, 1963*

Yield class[1]	Area
	Thousand acres
120 cubic feet or more	5,686
85 to 120 cubic feet	4,665
50 to 85 cubic feet	6,270
Less than 50 cubic feet	770
Total, all classes	17,391

[1]Based on potential yields in cubic feet per acre of mean annual growth at culmination of increment in fully stocked stands.

Table 7.--*Volume of timber on commercial forest land, by class of timber and species group, California, 1963*

Class of timber	All species	Softwoods	Hardwoods
	Million cubic feet		
Sawtimber trees:			
Sawlog portion	43,656	43,530	126
Upper-stem portion	6,469	6,469	0
Total	50,125	49,999	126
Poletimber trees	5,173	4,862	311
All growing-stock trees	55,298	54,861	437
Sound cull trees:			
Sawtimber-size trees	693	50	643
Poletimber-size trees	30	11	19
Total	723	61	662
Rotten cull trees:			
Sawtimber-size trees	913	737	176
Poletimber-size trees	41	11	30
Total	954	748	206
Salvable dead trees:			
Sawtimber-size trees	199	199	0
Poletimber-size trees	0	0	0
Total	199	199	0
Total, all timber	1/57,174	55,869	1,305

[1]Estimates of additional volumes on unproductive forest land total 5,401 million cubic feet in trees 5.0 inches and larger d.b.h., including 2,786 million cubic feet of softwoods and 2,615 million cubic feet of hardwoods.

Table 8.--*Volume of growing-stock and sawtimber on commercial forest land, by ownership classes and species group, California, 1963*

Ownership class	All species	Softwoods	Hardwoods
GROWING-STOCK			
	Million cubic feet		
National forest	29,163	28,905	258
Other public	2,145	2,128	17
Forest industry	8,960	8,900	60
Farmer and misc. private	15,030	14,928	102
Total, all ownership	55,298	54,861	437
SAWTIMBER			
	Million board feet[1]		
National forest	162,103	161,200	903
Other public	11,631	11,563	68
Forest industry	48,664	48,423	241
Farmer and misc. private	81,514	81,112	402
Total, all ownership	303,912	302,298	1,614

[1]International 1/4-inch log rule.

Table 9.--*Volume of growing-stock and sawtimber on commercial forest land, by species, California, 1963*

Species	Growing-stock	Sawtimber
	Million cubic feet	*Million board feet*[1]
Softwoods:		
Douglas-fir	17,761	98,973
Ponderosa pine[2]	10,496	58,398
Sugar pine[3]	4,112	25,031
True firs	13,804	75,303
Redwood	5,502	30,981
Other softwoods	3,186	13,612
Total	54,861	302,298
Hardwoods	437	1,614
Total, all species	55,298	303,912

[1]International 1/4-inch log rule.
[2]Includes Jeffrey pine.
[3]Includes Western white pine.

Table 10.--*Volume of growing-stock and sawtimber on commercial forest land, by diameter class and species group, California, 1963*

GROWING-STOCK

Species group	All classes	Diameter class (inches)				
		5.0-10.9	11.0-18.9	19.0-28.9	29.0-38.9	39.0 and larger
	Million cubic feet					
Softwoods	54,861	4,862	9,383	12,340	11,556	16,720
Hardwoods	437	311	52	50	20	4
Total, all species	55,298	5,173	9,435	12,390	11,576	16,724

SAWTIMBER

Species group	All classes	5.0-10.9	11.0-18.9	19.0-28.9	29.0-38.9	39.0 and larger
	Million board feet[1]					
Softwoods	302,298	--	31,433	73,167	79,035	118,663
Hardwoods	1,614	--	617	651	268	78
Total, all species	303,912	--	32,050	73,818	79,303	118,741

[1]International 1/4-inch log rule.

Table 11.--*Average annual net growth of growing-stock and sawtimber on commercial forest land, by species, California, 1962*

Species	Net annual growth	
	Thousand cubic feet	*Thousand board feet*[1]
Softwoods:		
Douglas-fir	172,484	954,560
Ponderosa pine[2]	116,666	663,947
Sugar pine[3]	38,330	251,070
True firs	180,869	945,221
Redwood	92,231	480,313
Other softwoods	43,122	207,770
Total	643,702	3,502,881
Hardwoods	6,903	23,919
Total, all species	650,605	3,526,800

[1]International 1/4-inch log rule.
[2]Includes Jeffrey pine.
[3]Includes Western white pine.

Table 12.--*Annual mortality of growing-stock and sawtimber on commercial forest land, by causes and species group, California, 1962*[1]

Cause of death	All species	Softwoods	Hardwoods
GROWING-STOCK			
	Thousand cubic feet		
Fire	92,821	91,173	1,648
Insects	53,865	53,865	0
Disease	84,766	84,640	126
Other	183,656	181,196	2,460
Total, all causes	415,108	410,874	4,234
SAWTIMBER			
	Thousand board feet[2]		
Fire	516,111	510,283	5,828
Insects	355,164	355,164	0
Disease	453,061	452,616	445
Other	925,882	917,079	8,803
Total, all causes	2,250,218	2,235,142	15,076

[1]Mortality figures represent average annual losses over a ten to fifteen year period, rather than actual mortality for 1962.

[2]International 1/4-inch log rule.

Table 13.--*Timber cut from growing stock and sawtimber on commercial forest lands, by products, California, 1962*

Products	Growing stock	Sawtimber
	Thousand cubic feet	*Thousand board feet*[1]
Roundwood products:		
Sawlogs	652,489	4,502,177
Veneer logs and bolts	93,636	720,995
Cooperage logs and bolts	0	0
Pulpwood	517	2,956
Piling	406	2,031
Poles	2,114	9,643
Mine timber	246	1,061
Misc. industrial wood	1,912	15,681
Posts	359	2,925
Fuelwood	2,510	9,645
All products	754,189	5,267,114
Logging residues	163,791	460,728
Timber cut	917,980	5,727,842

[1]International 1/4-inch log rule.

Table 14.--*Annual cut of growing-stock and sawtimber on commercial forest land, by species, California, 1962*

Species	Growing-stock	Sawtimber
	Thousand cubic feet	*Thousand board feet*[1]
Softwoods:		
Douglas-fir	366,790	2,342,659
Ponderosa pine[2]	140,826	878,029
Sugar pine[3]	64,697	402,628
True firs	138,493	868,460
Redwood	166,297	1,034,858
Other softwoods	27,186	168,621
Total	904,289	5,695,255
Hardwoods	13,691	32,587
Total, all species	917,980	5,727,842

[1]International 1/4-inch log rule.
[2]Includes Jeffrey pine.
[3]Includes Western white pine.

Accuracy

Data presented in this report were developed by sampling procedures. In varying degree, all the data are subject to the possibility of error. Errors could have been introduced through mistakes in classifying, measuring, tabulating, or reporting; through faulty judgment; or through the use of sampling procedures. Errors may or may not be compensating. Except for sampling error, there is no way of measuring them, but the chances of human error were reduced as far as possible by following detailed plans, by intensive training of personnel, and by careful supervision and checking of the work.

Sampling error accounts for errors that arise from taking a sample rather than making a complete inventory or measurement; it does not include possible errors resulting from human mistakes or faulty judgment. The sampling error of an estimate is given here in terms of one standard error, i. e., the range about the estimate within which the odds are two to one that the value based on 100 percent coverage would fall.

Analysis of the California forest inventory data indicates a sampling error of $\pm$ 0.6 percent for the estimate of total commercial forest land area, 1.7 percent for total cubic volume of growing stock, and 7.2 percent for total volume of net growth in cubic feet.

As area or volume data are subdivided by forest type, species, ownership, or other breakdown, the possibility of error increases and is greatest for the smallest item. The order of the increase is indicated in the following tabulation of sampling errors...

For commercial forest area:

Area (thousand acres)	Sampling error (percent)
17,391	0.6
5,000	1.1
1,000	2.6
100	8.1

For inventory volume:

Growing stock (million cu.ft.)	Sampling error (percent)
55,298	1.7
30,000	2.3
1,000	12.6
100	40.0

For average net annual growth of growing stock:

Volume (million cu.ft.)	Sampling error (percent)
651	7.2
200	13.0
50	26.0
5	82.1

Comparison with 1953 Inventory

The 1963 re-inventory shows more commercial forest land and less timber volume than in the 1953 survey. Part of the difference reflects actual physical change of the resource. Part is attributed to changes in procedures and definitions used in the inventories. And the remainder is due to sampling error. Consequently some statistics from the two inventories are not directly comparable.

Commercial Forest Land

Reported commercial forest land area increased from 17, 317, 000 acres (1953) to 17, 391, 000 acres (1963). This increase of 0. 4 percent reflects an increase in the estimate of commercial forest land in southern California based upon a reclassification of forested areas there. For the remainder of the State, additions to commercial forest area through reforestation and reclassifications were offset by withdrawals for dams, rights-of-way, and other developments, resulting in negligible net change during the period.

Sawtimber Volume

Sawtimber volume is down from 360 billion board feet in 1953 to 304 billion board feet in 1963. Much of the difference represents an actual reduction in inventory, as to be expected in a region where large amounts of old-growth timber contribute little net growth but support a large annual cut.

Imbalance between growth and annual cut accounts for about half the difference between inventories. Some of the difference is due primarily to changes in standards of utilization, in procedures, and in definitions. Additionally, in 1962, field crews identified many cull indicators that had been overlooked in the 1953 inventory. The result is a drop in net volumes. Finally, sampling errors associated with the two inventories account for some of the difference between inventories.

Growth and Mortality

Average net annual growth increased from 2.9 billion board feet for the period preceding 1953 to 3.5 billion board feet for the period 1953 through 1962. This increase reflects the continued change in stand structures as old-growth stands with little or no net growth are cut, and as second-growth stands reach sawtimber size.

Average annual mortality for the 10-year period was 2.25 billion board feet, or 20 percent greater than the 1.87 billion board feet reported in the 1953 inventory.

Procedures

Initial Survey

The initial survey for California was completed in 1952. The survey was based upon aerial photo delineation of the State's forested areas into several strata, transfer of the stratified areas to base maps from which area information was derived, and establishment of more than 1,500 field plots within the various strata to estimate volume.

Re-inventory

In 1962, Forest Survey field crews remeasured a sample of the initial survey field plots. Information on diameter increment, ingrowth, distribution of cut by diameter, mortality, and present volume was derived from these plots.

Volume

The January 1, 1963 estimates of volume are based on regression relationships developed from past and present volumes on the remeasured field plots, as applied to all of the initial survey field plots.

Commercial Forest Area

Area estimates of commercial forest land are based on the initial photo-delineation adjusted for changes in land classification during the past 10-years. This procedure was used for most of the State. For southern California, however, the estimate of commercial forest land area is based upon a re-evaluation, by photo point inspection on recent photography, and subsequent field checks.

Growth and Mortality

Growth estimates are based on the diameter increment of trees remeasured on the sample field plots. Estimates of mortality are based on trees that died during the interval between measurements.

Timber Cut

Timber cut estimates were derived by applying wood residue factors to the volume of roundwood harvested from California's forest lands in 1962. The roundwood harvest estimate was based upon a survey of all known users of roundwood material.

Definition of Terms

Commercial forest land: Forest land that is producing or capable of producing crops of industrial wood and is not withdrawn from timber use by statute or administrative regulation; includes areas suitable for management to grow crops of industrial wood and generally capable of producing in excess of 25 cubic feet per acre of annual growth; includes both accessible and prospectively accessible areas and both operable and prospectively operable areas.

Commercial species: Tree species now or prospectively suitable for industrial wood products; excludes so-called weed species.

Cull trees: Live trees that do not contain at least one merchantable sawlog, now or prospectively, because of roughness, rot, or species (also see sound cull trees and rotten cull trees).

Diameter classes: A classification of trees based on diameter of the tree outside bark, measured at breast height (4-1/2 feet above the ground). D.b.h. is the common abbreviation for "diameter at breast height."

Farmer-owned lands: Lands owned by operators of farms.

Forest industry lands: Lands owned by companies or individuals operating wood-using plants.

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not now developed for nonforest use; includes chaparral areas in the West and afforested areas. The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams, and clearings in forest areas are classed as forest if less than 120 feet in width. (See also commercial forest land, noncommercial forest land, productive-reserved forest land, and unproductive forest land.)

Forest types: A classification of forest land based upon the tree species now forming most of stocking. Where no species comprises a majority of a stand, types are based on plurality of stocking, excepting in the case of redwood and sugar pine in which the basis is that 20 percent or more of the stand be composed of the key species.

Growing-stock trees: Live sawtimber trees, poletimber trees, saplings, and seedlings of commercial species meeting specified standards of quality or vigor that are now or may be expected to become suitable for use as industrial wood; excludes cull trees.

Indian lands: Tribal lands held in fee by the Federal Government but administered for Indian tribal groups and Indian trust allotments.

Industrial wood: All commercial roundwood products, such as sawlogs and pulpwood, but excluding fuelwood and posts.

Land area: (a) Census definition--the area of dry land and land temporarily or partially covered by water, such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than one-eighth of a statute mile in width; and lakes, reservoirs, and ponds less than 40 acres in area. (b) Forest Survey definition--same as above except maximum width of streams, etc., is 120 feet and maximum size of lakes, etc., is 1 acre.

Logging residues: The unused portions of poletimber and sawtimber trees cut or killed by harvesting timber, land clearing, or cultural operations.

Miscellaneous Federal lands: Federal lands other than National Forests, lands administered by the Bureau of Land Management, and Indian lands.

Miscellaneous private lands: Privately owned lands other than forest industry or farmer-owned lands.

Mortality: The volume of sound wood in live sawtimber and poletimber trees (growing-stock trees) dying from natural causes during a specified period.

National Forest land: Federal lands that have been designated by Executive Order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

Net annual growth: The average annual change in volume of sound wood in live sawtimber and poletimber trees resulting from natural causes, i. e., increase in volume in absence of mortality and cutting, minus mortality, plus growth on mortality and growth on one-half the cut during a specified period.

Net volume: Gross volume less deductions for defects, excluding cull trees--

> Growing stock: Gross cubic-foot volume less deductions for rot and missing sections.
>
> Sawtimber: Gross board-foot volume less deductions for rot, sweep, crook, missing sections, and other defects that affect use for lumber.

Noncommercial forest land: Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions, and productive forest land withdrawn from commercial timber use through statute or administrative regulation.

Nonforest land: Land that has never supported forests and lands formerly forested but now developed for such nonforest uses as crops, improved pasture, residential areas, and city parks, improved roads, and adjoining rights-of-way, powerline clearings, and certain areas of water classified by the Bureau of the Census as land (see definition of land area). In forest areas, unimproved roads, streams, canals, and nonforest strips must be more than 120 feet wide; and clearings in forest areas must be more than 1 acre in size, to qualify as nonforest land.

Nonstocked areas: Commercial forest land less than 10 percent stocked with growing-stock trees.

Old-growth sawtimber stands: Sawtimber stands in which 50 percent or more of the net board-foot volume is in old-growth sawtimber trees.

Old-growth sawtimber trees: Trees that have reached or passed the age of physiological maturity.

Ownership: The property owned by one owner, including all parcels of land in the United States.

Poletimber stands: Stands at least 10 percent stocked with growing-stock trees, and with poletimber trees making up a plurality of this stocking.

Poletimber trees: Live trees of commercial species 5.0 to 10.9 inches in diameter at breast height, and of good form and vigor.

Productive-reserved forest land: Productive public forest land withdrawn from timber use through statute or administrative regulation.

Rotten cull trees: Live trees of commercial species, 5.0 inches and larger in diameter at breast height, that do not contain at least one minimum sawlog, now or prospectively, and have less than 25 percent of their volume in sound wood primarily because of rot (e.g., when rot accounts for 50 percent or more of the total cull volume).

Rough trees (sound cull trees): Live trees, 5.0 inches or larger in diameter at breast height, that do not contain at least one minimum sawlog, now or prospectively, and have less than 25 percent of their volume in usable form primarily because of roughness, poor form, or noncommercial species.

Roundwood products: Logs, bolts, or other round sections cut from trees.

Salvable dead trees: Standing or down dead trees, 11.0 inches or more in diameter at breast height, that contain at least one merchantable sawlog and 25 percent or more of sound wood volume.

Saplings: Live trees of commercial species, 1.0 to 5.0 inches in diameter at breast height and of good form and vigor.

Sapling-seedling stands: Stands at least 10 percent stocked with growing-stock trees and with saplings or seedlings or both making up a plurality of this stocking.

Sawlog: A log meeting minimum approved log-grade specifications; or, for species for which approved log grades are lacking, a log at least 10 feet long, with a minimum d.i.b. of 10 inches, and with a net scale of at least 30 board feet.

Sawlog portion: That part of the bole of sawtimber trees between the stump and the sawlog top.

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, and with sawtimber trees making up a plurality of this stocking.

Sawtimber trees: Live trees, 11.0 inches or larger in diameter at breast height, containing at least one minimum sawlog.

Seedlings: Established live trees of commercial species, less than 1.0 inch in diameter at breast height and of good form and vigor.

Stand-size classes: A classification of forest land based on the predominant size of timber present, that is, sawtimber, poletimber, saplings, and seedlings.

State, county, and municipal lands: Lands owned by States, counties, and local public agencies, or lands leased by these governmental units for more than 50 years.

Stocking: A measure of the degree to which area is occupied or used by trees of specified classes, including (a) all live trees, (b) growing-stock trees, and (c) desirable trees. Classification of forest land and forest types is based on stocking of all live trees. Stocking of growing-stock trees is used to determine stand-size and age class.

Stocking standards: The minimum number of well-spaced trees required to use fully the area by specified forest types and sites.

Timber cut from growing stock: The volume of sound wood in live sawtimber and poletimber trees cut for forest products during a specified period, including both roundwood products and logging residues.

Timber cut from sawtimber: The net board-foot volume of live sawtimber trees cut for forest products during a specified period, including both roundwood products and logging residues.

Timber products: Roundwood products and byproducts of primary wood manufacturing plants; includes sawlogs, veneer logs and bolts, cooperage logs and bolts, pulpwood, fuelwood, piling, poles, posts, hewn ties, mine timbers, and other round, split, or hewn products.

Tree-size classes: A classification of growing-stock trees according to diameter at breast height outside bark, including sawtimber trees, poletimber trees, saplings, and seedlings.

Unproductive forest land: Forest land incapable of yielding crops of industrial wood because of adverse site conditions; includes sterile or poorly drained forest land, subalpine forests, and steep, rocky areas where topotraphic conditions are likely to prevent management for timber production.

Upper-stem portion: That part of the bole of sawtimber trees above the merchantable top to a minimum top diameter of 4.0 inches outside bark, or to the point where the central stem breaks into limbs.

Volume of growing stock: The cubic-foot volume of sound wood in the bole of noncull sawtimber and poletimber trees of commercial species from a 1-foot stump to a minimum 4.0-inch top outside bark or to the point where the central stem breaks into limbs.

Volume of salvable dead sawtimber-size trees: Net volume of dead sawtimber-size trees, standing or down, that are considered merchantable by regional standards.

Volume of sawtimber: Net volume of the sawlog portion of live sawtimber trees in board feet (International 1/4-inch log rule).

Yield classes: A classification of forest land in terms of inherent capacity to grow crops of industrial wood.

Young-growth sawtimber stands: Sawtimber stands in which 50 percent or more of the net board foot volume is in young-growth sawtimber trees.

Young-growth sawtimber trees: Trees that have not passed the age of physiological maturity.

Tree Species

Principal tree species found on the commercial forest land in California include:

Common name	Scientific name
SOFTWOODS	
Redwood	*Sequoia sempervirens* (D. Don) Endl.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Ponderosa pine	*Pinus ponderosa* Laws.
Jeffrey pine	*Pinus jeffreyi* Grev. & Balf.
Sugar pine	*Pinus lambertiana* Dougl.
Western white pine	*Pinus monticola* Dougl.
California red fir	*Abies magnifica* A. Murr.
White fir	*Abies concolor* (Gord. & Glend.) Lindl.
Grand fir	*Abies grandis* (Dougl.) Lindl.
Incense-cedar	*Libocedrus decurrens* Torr.
Port-Orford-cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Western redcedar	*Thuja plicata* Donn.
Lodgepole pine	*Pinus contorta* Dougl.
HARDWOODS	
California black oak	*Quercus kelloggii* Newb.
Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
Quaking aspen	*Populus tremuloides* Michx.
Alder (white alder)	*Alnus rhombifolia* Nutt.
Alder (red alder)	*Alnus rubra* Bong.

GPO 973-295

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 5 1966

Forest Statistics for Del Norte County, California, 1965

Daniel D. Oswald and Gerald S. Walton

Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

Contents

The Authors

DANIEL D. OSWALD, formerly with the Station's Forest Survey staff, is now assigned to the Forest Survey staff of the Pacific Northwest Forest and Range Experiment Station, with headquarters in Berkeley. Native of Alameda, Calif., he is 1958 forestry graduate of the University of California and has also done graduate work there. After service with the U.S. Navy, he joined the Forest Service in 1962. GERALD S. WALTON, a digital computer programer on the Station's research staff, prepared the computer programs for processing inventory data from the Forest Survey. He was born in Leadville, Colo., received a B.A. degree in mathematics (1960) at the University of California, and a M.F.S. degree (1965) from Harvard University.

ACKNOWLEDGMENTS

Grateful acknowledgment is made of the assistance provided by the following offices and individuals: Division of Timber Management, California Region, Forest Service, which provided field plot data; Del Norte County Assessor, who provided ownership information and access to aerial photography; various private firms and individuals, who cooperated in the survey; and members of the Station's Forest Survey staff, who helped in collecting field data.

An inventory of Del Norte County's timber resources was completed in 1965. Results are reported in this publication. Past Forest Survey inventories have included Del Norte County, but they were not designed to obtain volume estimates for an individual county.

This publication is the first of a series reporting inventory findings for the important timber producing counties of California's North Coast.

This inventory is part of the nationwide Forest Survey, authorized by the McSweeney-McNary Forest Research Act of 1928. The Forest Survey periodically inventories the extent and condition of the forest lands and their timber resources, to determine the resource base, rates of forest growth and use, and trends in supply of raw materials for the wood products industries. Such information is needed in formulating forest policy and programs.

The Forest Survey is conducted by the Forest Service's regional experiment stations. The Del Norte County inventory was made by the Pacific Southwest Forest and Range Experiment Station.

Highlights

Commercial Forest Land

More than three-fourths--76 percent--of Del Norte County consists of commercial forest land.[1] Of the 487,000 acres of such land, 69 percent is publicly owned, and 31 percent privately owned. Sawtimber-size stands of timber occupy 68 percent of this land. More than half--55 percent--of the commercial forest land is occupied by Douglas-fir type; redwood type takes up 15 percent. All softwood types combined account for 80 percent of the commercial forests; and hardwoods the remaining 20 percent.

Growing Stock Volume

Growing stock in the county totals 2,211,000,000 cubic feet. Of this amount, 61 percent is Douglas-fir, and 28 percent redwood. Nearly the entire volume consists of softwood species and is in sawtimber-size trees Ownership is divided as follows: 67 percent publicly owned, and 33 percent privately owned.

Sawtimber Volume

Sawtimber-size trees total 12,836,000,000 board feet (International 1/4-inch log rule). Nearly three-fourths--70 percent--is publicly owned. And 65 percent is in trees 39.0 inches or larger (diameter breast height).

[1] See appendix for definition of terms.

Comparison with Previous Inventory

Information on timber volume for Del Norte County was not compiled separately in the State-wide initial survey completed in 1952, but area statistics for the county were compiled for 1948 and published.[2] The 1965 inventory suggests that commercial forest land in the county has increased by 36,000 acres from the previous survey.

This increase can be attributed to several factors. The 1952 acreage estimates were based on delineation to a 40-acre minimum; the 1965 estimates are based on classification of land to a 1-acre minimum. Some stands that were classified noncommercial owing to inaccessibility are now classified as commercial forest. And some land that had been cleared for nonforest use has become stocked with forest trees.

The differences in acreage by forest type reflect changes in type definitions. Owing to these changes, the forest type acreages from the two surveys cannot be compared.

---

[2] U.S. Forest Service California Forest and Range Experiment Station Forest Survey Rel. 18, 23 pp., illus. 1953.

Tables

Table 1.--*Land area, by major classes of land, Del Norte County, 1965*

Class of land	Area
	Acres
Forest:	
Commercial	486,943
Noncommercial	
Productive--reserved	12,766
Unproductive	107,163
Total forest	606,872
Nonforest	35,048
Total, all classes	641,920

Table 2.--*Commercial forest land area, by ownership and stand-size classes, Del Norte County, 1965*

Ownership	Total	Sawtimber stands	Poletimber stands	Seedling and sapling stands	Nonstocked areas
	Acres				
Federal:					
National Forest	333,672	257,514	29,158	38,852	8,148
Other public	(1/)	(1/)	(1/)	(1/)	(1/)
Private:					
Forest industry	129,670	63,574	--	59,975	6,121
Farm and misc. private	23,601	11,424	--	6,088	6,089
Total, all ownerships	486,943	332,512	29,158	104,915	20,358

[1] Less than 500 acres.

Table 3.--*Commercial forest land area, by major forest types*[1] *and ownership groups, Del Norte County, 1965*

Type	All ownership	Public ownership	Private ownership
	Acres		
Softwoods:			
Douglas-fir	266,010	229,246	36,764
Hemlock--sitka spruce	8,871	--	8,871
Redwood	71,075	14,739	56,336
Ponderosa pine	25,902	25,902	--
White pine (sugar pine)	5,424	5,424	--
Lodgepole pine	--	--	--
Fir--spruce	14,575	14,575	--
Hardwoods:	95,086	43,786	51,300
Total, all types	486,943	333,672	153,271

[1]The forest types presented in this table conform with standard types as defined by Forest Survey.

Table 4.--*Commercial forest land area, by yield class, Del Norte County, 1965*

Yield class (cubic feet)[1]	Total	National forest	Other public	Forest industry	Farm & misc. private
	Thousand acres				
120 or more	254,173	142,116	(2/)	94,119	17,938
85 to 120	89,720	71,298	(2/)	15,410	3,012
50 to 85	105,092	91,322	(2/)	11,119	2,651
Less than 50	37,958	28,936	(2/)	9,022	0
Total, all classes	486,943	333,672	(2/)	129,670	23,601

[1]Based on potential yields in cubic feet per acre of mean annual growth at culmination of increment in fully stocked stands.

[2]Less than 500 acres.

Table 5.--*Commercial forest land area, by stocking classes of growing-stock trees and by stand-size classes, Del Norte County, 1965*

Stocking class	All stands	Sawtimber stands	Poletimber stands	Seedling and sapling stands	Nonstocked stands
	Acres				
Well-stocked	237,799	197,309	10,583	29,907	--
Medium-stocked	128,246	74,742	3,235	50,269	--
Poorly-stocked	100,540	60,461	15,340	24,739	--
Nonstocked	20,358	--	--	--	20,358
Total, all classes	486,943	332,512	29,158	104,915	20,358

Table 6.--*Commercial forest land area, by stand volume classes, Del Norte County, 1965*

Stand volume per acre (board feet)[1]	Area
	Acres
Less than 1,500	126,092
1,500 to 2,500	18,510
2,500 to 5,000	36,935
5,000 to 7,500	35,574
7,500 to 10,000	16,663
More than 10,000	253,169
Total, all classes	486,943

[1]Net volume, International 1/4-inch log rule.

Table 7.--*Volume of timber on commercial forest land, by class of timber and species group, Del Norte County, 1965*

Class of timber	All species	Softwoods	Hardwoods
	Million cubic feet		
Sawtimber trees	2,150	2,117	33
Poletimber trees	61	48	13
All growing-stock trees	2,211	2,165	46
Sound cull trees:			
Sawtimber-size trees	51	10	41
Poletimber-size trees	41	2	39
Total	92	12	80
Rotten cull trees:			
Sawtimber-size trees	61	42	19
Poletimber-size trees	4	--	4
Total	65	42	23
Salvable dead trees:			
Sawtimber-size trees	6	6	0
Poletimber-size trees	0	0	0
Total	6	6	0
Total, all timber	2,374	2,225	149

Table 8.--*Volume of growing stock and sawtimber on commercial forest land, by ownership classes and species group, Del Norte County, 1965*

GROWING STOCK

Ownership class	All species	Softwoods	Hardwoods
	Million cubic feet		
National Forest	1,486	1,480	6
Other public	--	--	--
Forest industry	685	652	33
Farm and misc. private	40	33	7
Total, all ownership	2,211	2,165	46

SAWTIMBER

Ownership class	All species	Softwoods	Hardwoods
	Million board feet		
National Forest	9,014	9,002	12
Other public	--	--	--
Forest industry	3,624	3,560	64
Farm and misc. private	198	180	18
Total, all ownership	12,836	12,742	94

[1]International 1/4-inch log rule.

Table 9.--*Volume of growing stock and sawtimber on commercial forest land, by species, Del Norte County, 1965*

Species	Growing stock	Sawtimber
	Million cubic feet	*Million board feet*[1]
Softwoods:		
Douglas-fir	1,345	8,556
Redwood	625	3,144
True firs	75	400
Sugar pine	55	316
Western hemlock	20	113
Western redcedar	6	37
Ponderosa and Jeffrey pine	5	24
Western white pine	5	11
Incense-cedar	5	23
Sitka spruce	4	18
Other softwoods	20	100
Total	2,165	12,742
Hardwoods:		
Red alder	9	19
Oaks	32	65
Other hardwoods	5	10
Total	46	94
Total, all species	2,211	12,836

[1]International 1/4-inch log rule.

Table 10.--*Volume of sawtimber on commercial forest land, by diameter class and species, Del Norte County, 1965*

Species	All classes	Diameter class (inches) 5.0-10.9	11.0-18.9	19.0-28.9	29.0-38.9	39.0 and larger
	Million board feet[1]					
Softwoods:						
Douglas-fir	8,556	0	349	1,120	1,651	5,436
Redwood	3,144	0	44	177	309	2,614
True firs	400	0	72	198	79	51
Sugar pine	316	0	22	63	113	118
Western hemlock	113	0	2	22	25	64
Other softwoods	213	0	46	50	42	75
Total	12,742	0	535	1,630	2,219	8,358
Hardwoods:						
Red alder	19	0	13	6	0	0
Oaks	65	0	14	35	16	0
Other hardwoods	10	0	6	4	0	0
Total	94	0	33	45	16	0
Total, all species	12,836	0	568	1,675	2,235	8,358

[1]International 1/4-inch log rule.

Table 11.--*Volume of growing stock on commercial forest land, by diameter class and species, Del Norte County, 1965*

Species	All classes	Diameter class (inches) 5.0-10.9	11.0-18.9	19.0-28.9	29.0-38.9	39.0 and larger
	Million cubic feet[1]					
Softwoods:						
Douglas-fir	1,345	31	94	191	252	777
Redwood	625	2	10	40	65	508
True firs	75	3	15	35	14	8
Sugar pine	55	5	4	11	18	17
Western hemlock	20	1	([1])	4	4	11
Other softwoods	45	6	11	10	7	11
Total	2,165	48	134	291	360	1,332
Hardwoods:						
Red alder	9	4	4	1	0	0
Oaks	32	7	6	13	6	0
Other hardwoods	5	1	3	1	0	0
Total	46	12	13	15	6	0
Total, all species	2,211	60	147	306	366	1,332

[1]Less than 500 thousand cubic feet.

Table 12.--*Volume of salvable dead sawtimber-size trees on commercial forest land, by species group, Del Norte County, 1965*

Species group	Volume
	Million board feet[1]
Softwoods	34
Hardwoods	0
All species	34

[1]International 1/4-inch log rule.

Accuracy of Inventory Data

Estimates of forest land area and timber volume for Del Norte County were based on sampling and therefore include sampling errors.

Estimated sampling error--expressed as a percent of the total estimate at the 68-percent probability level--for forest area and timber volume is as follows:

Item	Estimated total	Sampling error (percent)
Commercial forest land	486,943 acres	±2.9
Growing stock volume	2,211,000 cu. ft.	±8.0
Sawtimber volume (Int. 1/4-inch rule)	12,836,000 bd. ft.	±8.2

The sampling error for any breakdown of the total area or volume estimates will be greater than those shown for the totals. Therefore, fine breakdowns have large percent sampling errors associated with them.

Errors due to reasons other than sampling--human errors--cannot be determined. Such errors have been kept to a minimum, however, by thorough training and close supervision of survey personnel and periodic checks of the work during all phases of the inventory.

Inventory Procedure

This inventory of Del Norte County combines data from the Six Rivers National Forest inventory project and the Forest Survey inventory project. The Six Rivers National Forest data were collected during the period 1961-1964. The remainder of the county, including part of the Siskiyou National Forest, was inventoried in 1964, and data compiled as of January 1, 1965. The same sampling design and field procedure were used throughout the county. No attempt was made to update the Six Rivers National Forest portion of the inventory for growth or cut.

A systematic grid of photo points was printed on aerial photos covering the entire County. Each photo point was classified by a trained photo interpreter. The points were then stratified into stand volume classes within commercial forest land, and noncommercial and nonforest land, based upon the photo classification.

A stratified random sample (with proportional allocation) was then drawn from the photo points. This sample of photo points was visited in the field. Each location visited was classified in the field as to land use and ownership. And for those locations falling on commercial forest land, a circular 2/5-acre inventory plot was established to provide information on volume, mortality, and forest type. The plots when remeasured will also yield information on growth.

Definition of Terms

Commercial forest land: Forest land which is producing or capable of producing crops of industrial wood and is not withdrawn from timber utilization. Includes accessible and inaccessible areas, and both operable and currently inoperable areas.

Commercial species: Tree species presently or prospectively suitable for industrial wood products; excludes so-called weed species.

Cull trees: Live trees that do not contain at least one merchantable sawlog, now or prospectively, because of roughness, rot, or species (see also sound cull trees and rotten cull trees).

Diameter classes: A classification of trees based on diameter of the tree outside bark, measured at breast height (4-1/2 feet above the ground). D. b. h. is the common abbreviation for "diameter at breast height."

Farmer-owned lands: Lands owned by operators of farms.

Forest industry lands: Lands owned by companies or individuals operating wood-using plants.

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use.

Forest type: A classification of forest land based upon the predominant species in the present tree cover. Types are determined on the basis of plurality of stocking by all live trees. For poletimber size trees and larger, stocking is determined from basal area occurrence, and for trees less than 5.0 inches d.b.h. from number of trees.

Growing-stock trees: Live sawtimber trees, poletimber trees, saplings, and seedlings of commercial species that are, or can be expected to become suitable for use as industrial wood. Excludes cull trees.

Industrial wood: All commercial roundwood products, such as sawlogs and pulpwood, but excluding fuelwood and posts.

Land area: The area of dry land and land temporarily or partially covered by water, such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than one-eighth of a statute mile in width; and lakes, reservoirs and ponds less than 40 acres in area.

Logging residues: The unused portions of poletimber and sawtimber trees cut, or killed by harvesting timber, land clearing, or cultural operations.

Miscellaneous private lands: Privately owned lands other than forest industry or farmer-owned lands.

National Forest land: Federal lands which have been designated by Executive Order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III lands.

Net volume: Gross volume less deductions for defects, excluding cull trees:

Growing stock: Gross cubic foot volume less deductions for rot and missing sections.

Sawtimber: Gross board-foot volume less deductions for rot, sweep, crook, missing sections, and other defects that affect use for lumber.

Noncommercial forest land: Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions, and productive forest land such as State and National parks and wilderness areas withdrawn from commercial timber use through statute or administrative regulation.

Nonforest land: Land that has never supported forests and lands formerly forested but now developed for nonforest uses, such as crops, improved pasture, residential areas and city parks, improved roads and adjoining rights-of-way, powerline clearings, and certain areas of water classified by the Bureau of the Census as land (see land area). In forest areas unimproved roads, streams, canals, and nonforest strips must be more than 120 feet wide, and clearings in forest areas must be more than 1 acre in size, to qualify as nonforest land.

Nonstocked areas: Commercial forest land less than 10 percent stocked with growing-stock trees.

Poletimber stands: Stands at least 10 percent stocked with growing-stock trees, and with poletimber trees making up a plurality of this stocking.

Poletimber trees: Live trees of commercial species 5.0 to 10.9 inches in diameter at breast height, and of good form and vigor.

Productive-reserved forest land: Productive public forest land such as State and National Parks and wilderness areas withdrawn from timber utilization through statute or administrative regulation.

Rotten cull trees: Live trees of commercial species, 5.0 inches and larger in diameter at breast height, that do not contain at least one minimum sawlog, now or prospectively, and have less than 25 percent of their volume in sound wood primarily because of rot.

Sound cull trees: Live trees, 5.0 inches or larger in diameter at breast height, that do not contain at least one minimum sawlog, now or prospectively, and have less than 25 percent of their volume in usable form primarily because of roughness, poor form, or noncommercial species.

Salvable dead trees: Standing or down dead trees, 11.0 inches or more in diameter at breast height, that contain at least one merchantable sawlog and 25 percent or more of sound wood volume.

Saplings: Live trees of commercial species, 1.0 to 5.0 inches in diameter at breast height and of good form and vigor.

Sapling-seedling stands: Stands at least 10 percent stocked with growing-stock trees and with saplings or seedlings or both making up a plurality of this stocking.

Sawlog: A log meeting minimum approved log-grade specifications; or, for species for which approved log grades are lacking, a log at least 10 feet long, with a minimum d. i. b. of 10 inches, and with a net scale of at least 30 board feet.

Sawlog portion: That part of the bole of sawtimber trees between the stump and the sawlog top.

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, and with sawtimber trees making up a plurality of this stocking.

Sawtimber trees: Live trees, 11.0 inches or larger in diameter at breast height, containing at least one minimum sawlog.

Seedlings: Established live trees of commercial species, less than 1.0 inch in diameter at breast height and of good form and vigor.

Stand-size classes: A classification of forest land based on the predominant size of timber present, that is, sawtimber, poletimber, saplings, and seedlings.

Stocking: A measure of the degree to which forest land is occupied by trees of specified classes in relation to a specified basal area standard for trees 5.0 inches d. b. h. and larger, or number of trees per acre for smaller trees; tree classes include (1) all live trees, and (2) growing stock trees.

Stocking classes:

Well-stocked stand: A stand that is 70 percent or more stocked with present or potential growing-stock trees.

Medium-stocked stand: A stand that is 40 to 69 percent stocked with present or potential growing-stock trees.

Poorly-stocked stand: A stand that is 10 to 39 percent stocked with present or potential growing-stock trees.

Nonstocked stand: An area less than 10 percent stocked with present or potential growing-stock trees.

Tree-size classes: A classification of growing-stock trees according to diameter at breast height outside bark, including sawtimber trees, poletimber trees, saplings, and seedlings.

Unproductive forest land: Forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Volume of growing stock: The cubic-foot volume of sound wood in the bole of noncull sawtimber and poletimber trees of commercial species from a 1-foot stump to a minimum 4.0-inch top outside bark or to the point where the central stem breaks into limbs.

Volume of salvable dead sawtimber-size trees: Net volume of dead sawtimber-size trees, standing or down, that are considered merchantable by regional standards.

Volume of sawtimber: Net volume of the sawlog portion of live sawtimber trees in board feet, International 1/4-inch log rule.

Yield classes: A classification of forest land based upon potential yields in cubic feet per acre of mean annual growth at culmination of increment in fully stocked stands.

Tree Species

Tree species found on the commercial forest land in Del Norte County include:

Softwoods

Redwood	*Sequoia sempervirens* (D. Don) Endl.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Ponderosa pine	*Pinus ponderosa* Laws.
Jeffrey pine	*Pinus jeffreyi* Grev. & Balf.
Sugar pine	*Pinus lambertiana* Dougl.
Western white pine	*Pinus monticola* Dougl.
California red fir	*Abies magnifica* A. Murr.
White fir	*Abies concolor* (Gord. & Glend.) Lindl.
Grand fir	*Abies grandis* (Dougl.) Lindl.
Incense-cedar	*Libocedrus decurrens* Torr.
Port-Orford-cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Western redcedar	*Thuja plicata* Donn.
Lodgepole pine	*Pinus contorta* Dougl.

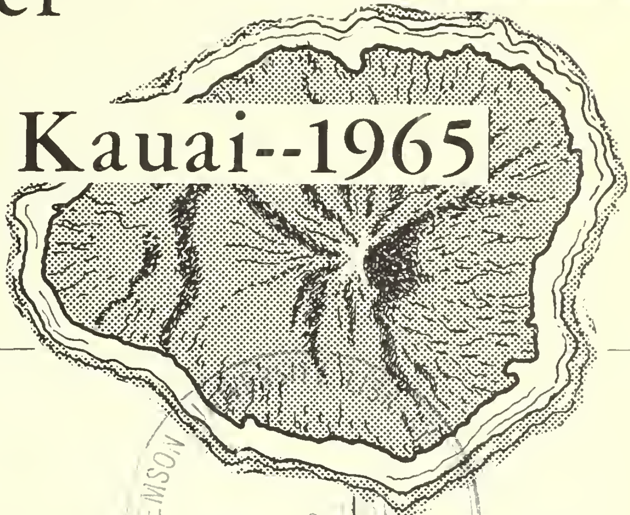
Hardwoods

California black oak	*Quercus kelloggii* Newb.
Tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
Red alder	*Alnus rubra* Bong.
Pacific madrone	*Arbutus menziesii* Pursh
Biglead maple	*Acer macrophyllum* Pursh

GPO 973-296

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 6   1967

Plantation Timber on the Island of Kauai--1965



Nobuo Honda
Wesley H. C. Wong, Jr.
Robert E. Nelson

Pcific Southwest Forest and Range
Eperiment Station, Forest Service,
US. Department of Agriculture,
Brkeley, California 94701

and

Division of Forestry,
Department of Land
and Natural Resources,
State of Hawaii,
Honolulu, Hawaii 96313

Foreword

This report is one of a series about planted timber on major islands in the State of Hawaii. The report for the Island of Hawaii was published in 1966. Summarized here are the results of a survey of timber in planted forests on the Island of Kauai. This inventory is a supplement to the initial Forest Survey of the State completed in 1963. That Survey indicated the importance of forest plantations as a timber resource, but provided no details. This bulletin reports: (a) location and acreage of each planted stand, (b) species composition and age of stand, (c) timber volume and quality, and (d) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, chief, Hawaii Forestry Research Center, Pacific Southwest Forest and Range Experimen- Station. Nobuo Honda, forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory and supervised the field work.

In 1966, responsibility for supervision of the Forest Survey in the Pacific Coast States and Hawaii was shifted to the Pacific Northwest Forest and Range Experiment Station, but field work in Hawaii will continue to be a joint effort of the Hawaii State Division of Forestry and the Pacific Southwest Station's Forestry Research Center in Hawaii.

Many individuals aided in various phases of the Survey. Special acknowledgment is due to the field crew: Forester W. Wong and crew members M. S. Andrade, M. H. Andrade, and E. Petteys--all of the Hawaii Division of Forestry.

E. M. Hornibrook, formerly in charge of the Forest Survey, Pacific Southwest Station, and Russell K. LeBarron, former forest ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, systems analyst, Pacific Southwest Station, developed specifications for processing data by electronic computers. The Computing Center at the University of Hawaii processed the data.

Max F. Landgraf, State forester, and Ralph E. Daehler, district forester, State of Hawaii provided generous cooperation and assistance in the conduct of the survey.

OXFORD: (969):524.61:228.7. *RETRIEVAL TERMS:* Forest surveys; Hawaii; Kauai; plantations.

Contents

The Authors

NOBUO HONDA, a native of Kona, Hawaii, received his bachelor's degree in forestry from Humboldt State College in 1960. As timber survey forester for the Hawaii Division of Forestry since April 1960, he has been assigned primarily to the forest inventory of the State. WESLEY H. C. WONG, Jr., a native of Wailuku, Maui, received his bachelor's degree in forestry from Oregon State University in 1964. He joined the Hawaii Division of Forestry in August 1964. He has been primarily responsible for gathering field data for the forest inventory. ROBERT E. NELSON is chief of the Station's Hawaii Research Center, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office.

Planted sugi groves in the Na Pali Kona Forest Reserve. Some of the finest recreational areas in the Reserve are found here.

The Island of Kauai lies at the northwest end of the Hawaiian chain. Formed by volcanic action, most of the island's 551 square miles of land is of steep, rugged, mountainous topography. But in the "coastal plains" there are areas of level or gently sloping lands. Mt. Waialeale rises to 5,080 feet in the center of the island. This peak is reportedly the wettest spot on earth, with an average annual rainfall of 466 inches. Rainfall is much less in coastal areas just a few miles away, where less than 20 inches fall in some parts of the southwest shore.

Sugar production is the most important industry on the island. Most lands suited to growing sugar cane are used for that purpose. Pineapple production has decreased sharply in recent years; relatively little acreage is used for this or other cultivated crops.

Cattle graze on a large acreage throughout most of Kauai. Although much of the grazed land is forested, grazing is excluded from large areas of Forest Reserves.

The Reserves are public and private lands administered by the State for the management and protection of watersheds and other forest values.

Tourism is important to the island's economy. Kauai's verdant beauty and rugged scenery attract many tourists each year.

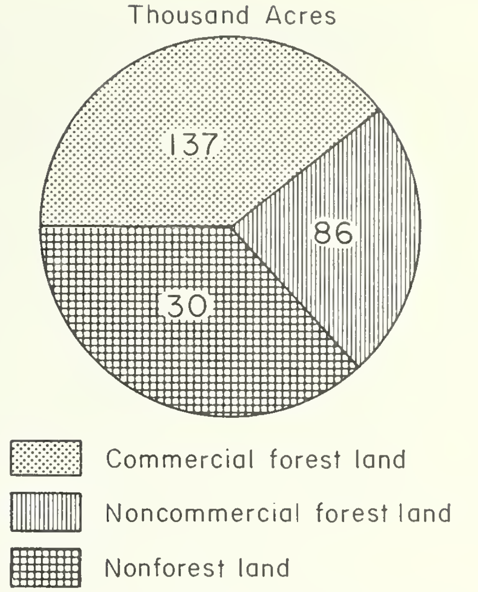


Figure 1.--*Forest and nonforest land acreages on the Island of Kauai, 1961.*

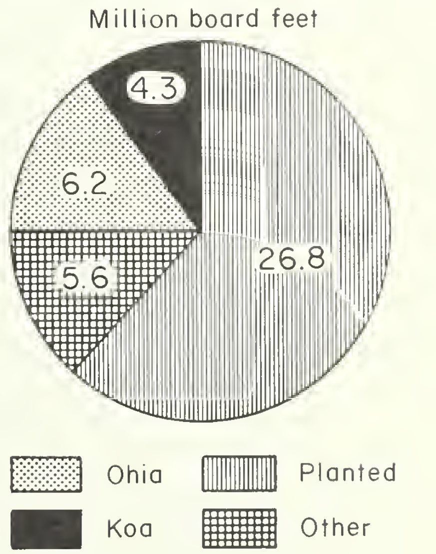


Figure 2.--*Sawtimber volumes on the Island of Kauai, 1961.*

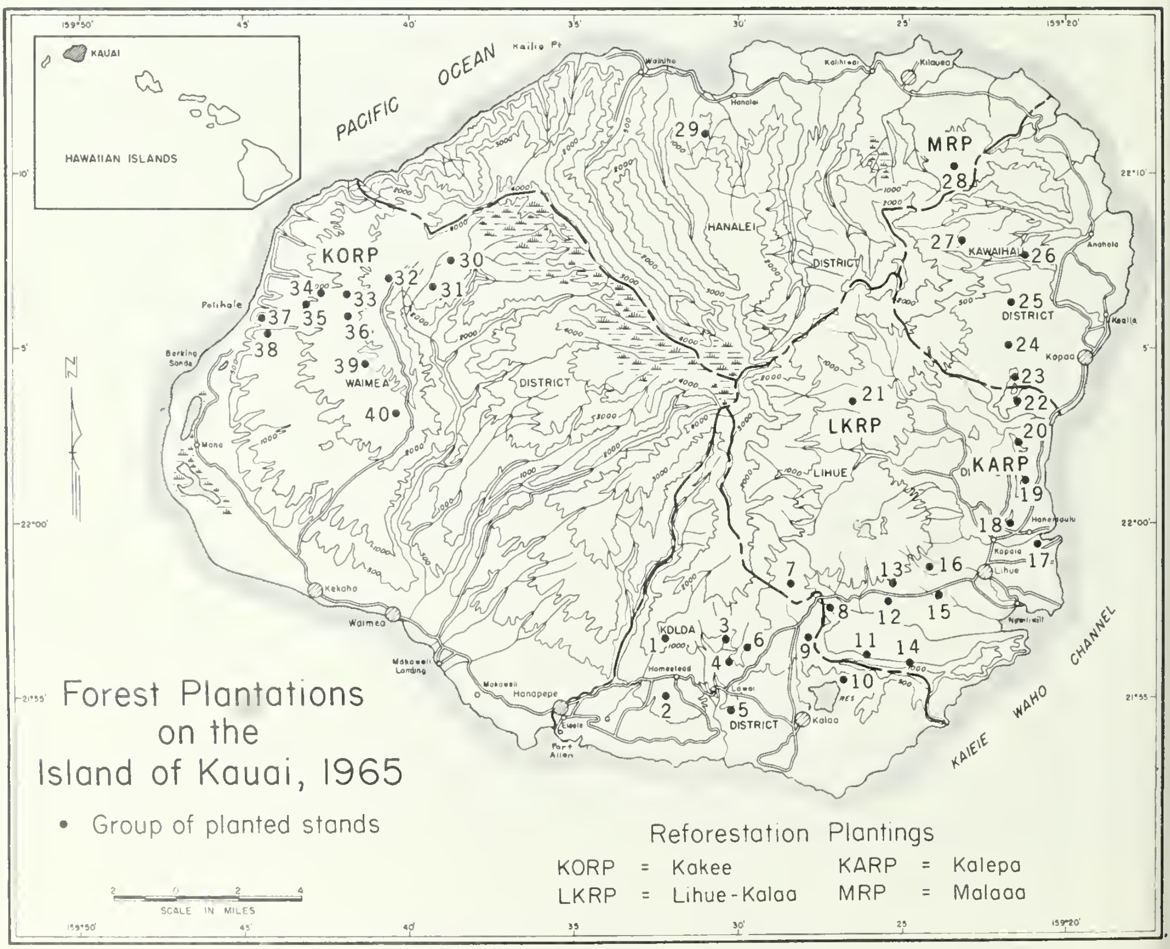
The first forest inventory in Hawaii found that a high proportion of the Island of Kauai is forest land.[1] Of its total land area of 353,000 acres, some 137,000 acres are commercial forest land, holding about 43 million board feet of sawtimber. In addition, there are about 86,000 acres of noncommercial forest land (fig. 1,2).

[1]Nelson, Robert E., and Wheeler, Philip R. *Forest resources of Hawaii--1961.* Forestry Div., Dep. Land and Natural Resources, State of Hawaii, in cooperation with the Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr., 48 pp., illus. 1963.

By far, most of the forest acreage is native or naturalized types. These forests contain little volume of sawtimber. Only about 25,000 acres of the ohia (*Metrosideros collina*), koa (*Acacia koa*)[2] and naturally regenerated silk-oak (*Grevillea robusta*) types were considered commercial types in the initial forest survey.[1] Sawtimber in these stands amounts to about 16 million board feet. Nearly 110,000 acres of commercial forest land have noncommercial forest or brush cover.[1]

The small acreage of planted forests of introduced species on the Island of Kauai holds more volume of sawtimber than do the native forests. Plantation yields per acre are much greater and timber is generally of higher quality than native timber. These forest plantings were started more than 50 years ago, principally to develop a supply of fuelwood and fence posts for sugar plantations and ranches. In the late 1930's and early 1940's, plantings were accelerated by the State Division of Forestry to develop a timber supply for the future.

[2] A small acreage of planted koa forest is included in the over-all acreage of native forest type because of the difficulty of differentiation. In general, the planted koa forest has not developed into good timber stands.



Forest Plantations on the Island of Kauai, 1965

• Group of planted stands

Reforestation Plantings

KORP = Kokee
LKRP = Lihue-Kalaa
KARP = Kalepa
MRP = Malaaa

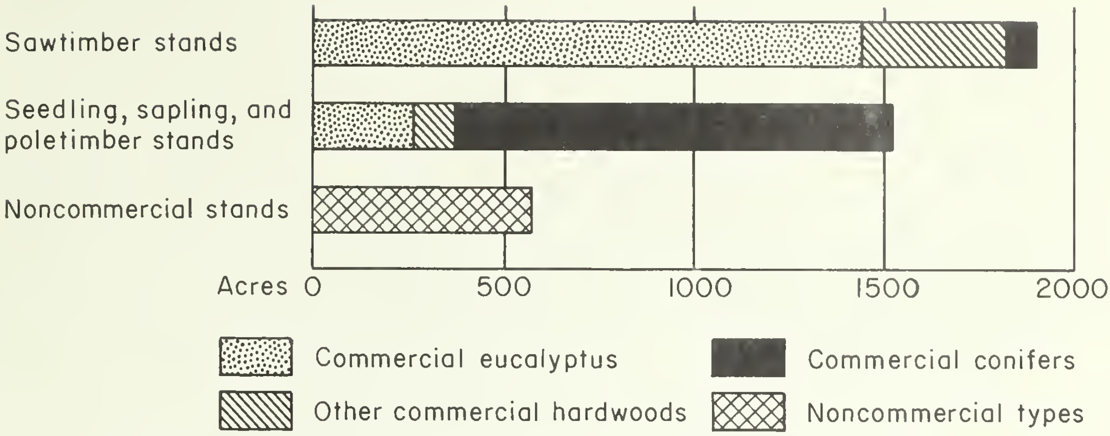


Figure 3.--*Acreage of commercial and noncommercial plantation stands, by stand-size class and forest type, Island of Kauai, 1965.*

Although the total volume is only about 27 million board feet, the plantation timber is mostly accessible and has a greater potential for industrial use than the native timber. Therefore, in 1965 we made a stand-by-stand inventory to obtain information on the plantation acreage and timber volume, quality, and ownership. This report summarizes data compiled for each plantation stand.

Forest Plantations

Timber Resources

Forest plantations on the Island of Kauai are distributed chiefly on the eastern, southeastern, and western portions of the island (see map and tables 10 and 11). In the east and southeast, most plantations are located 1 to 6 miles inland at elevations from 500 feet to 1,200 feet. In the west, plantings are from 3 to 8 miles inland and from 2,000 to 3,000 feet in elevation. The faster growing and higher volume-producing stands generally lie in the higher rainfall areas.

Earlier plantings, before the Civilian Conservation Corps programs of the late 30's, were in gullies and areas bordering croplands where sugar and pineapple could not be grown. Agricultural roads make these stands accessible. The CCC program, with its large labor force and slightly different objectives, concentrated on planting the steeper slopes and rugged mountain ridges. Access then was mostly by foot and horse trails. These areas now are not far from good access roads or jeep trails.

Area

Commercial forest plantations[3] on the Island of Kauai total more than 3,400 acres in stands from 2 to 68 acres in size (tables 1-4; fig. 3). About 1,900 acres of these plantations are sawtimber stands. Another 1,500 acres are recently planted

---

[3]See definitions of terms in Appendix.

Molucca albizzia stands yield high sawtimber volumes. This stand No. 2160 averages 33,310 board feet per acre.

Eucalypts make up 70 percent of the sawtimber volume on Kauai, where mixed eucalyptus plantings are common. This stand of saligna (white bark) and tallowwood eucalyptus averages 37,000 board feet per acre.

seedling, sapling, and poletimber stands of commercial species, mostly conifers.

Eucalypts, mainly *Eucalyptus robusta*, make up 76 percent, or about 1,400 acres of the sawtimber stands. The acreage of hardwood sawtimber stands other than eucalypts totals about 370, and there are just under 100 acres of commercial conifer sawtimber stands. Pines (*Pinus* spp.) and other commercial conifers amount to about 76 percent of the recent plantings.

Besides commercial forest plantations there are nearly 600 acres of noncommercial types, mostly ironwood and paper-bark.

Timber Volume

Planted forests on Kauai contain nearly 27 million board feet of sawtimber (tables 5,6). Of the total, eucalyptus sawtimber makes up 70 percent, or nearly 19 million board feet. Robusta eucalyptus sawtimber alone amounts to 14.6 million board feet. Sawtimber volume in hardwoods other than eucalypts totals about 6 million board feet. Commercial conifers, such as Norfolk-Island-pine, sugi, and redwood, total nearly 2.2 million board feet.

About 40 percent of the sawtimber volume is in trees 19 to 29 inches d.b.h. (table 7). About 50 percent of the total volume is in trees smaller than 19 inches, and about 10 percent is in trees larger than 29 inches d.b.h.

The total growing stock volume in planted sawtimber stands amounts to about 5.7 million cubic feet (table 5). More than 72 percent, or about 4.2 million cubic feet of this volume, is in eucalypts. Robusta eucalyptus totals some 3.3 million cubic feet of growing stock. Other hardwoods total 1.1 million cubic feet, and conifers make up the remainder with less than 0.5 million cubic feet.

Poletimber and sapling and seedling stands contain additional volume of growing stock, but they were not measured.

Wood in cull trees in planted sawtimber stands totals nearly one-half million cubic feet (table 8). The 570 acres of noncommercial plantations hold an additional, much greater volume of wood in cull trees, but these stands were also not measured.

Ownership

The State of Hawaii owns nearly half of the forest plantations on the Island of Kauai (tables 2 and 9; fig. 4). Of the 3,994 acres tallied, including noncommercial types, the State owns 1,677 acres, or about 42 percent. Additional public ownership is Hawaiian Homes land amounting to 1,033 acres. This land is State-owned, set aside and administered by the Hawaiian Homes Commission for the benefit of people of Hawaiian ancestry. Private owners have 1,255 acres, or 31 percent; and county and municipal lands have 29 acres of forest plantations.

In volume, the State owns a lesser proportion of the timber because a substantial area of the State-owned plantations are the younger seedling, sapling, and pole-size stands. And a large portion of private stands are those in the older age groups

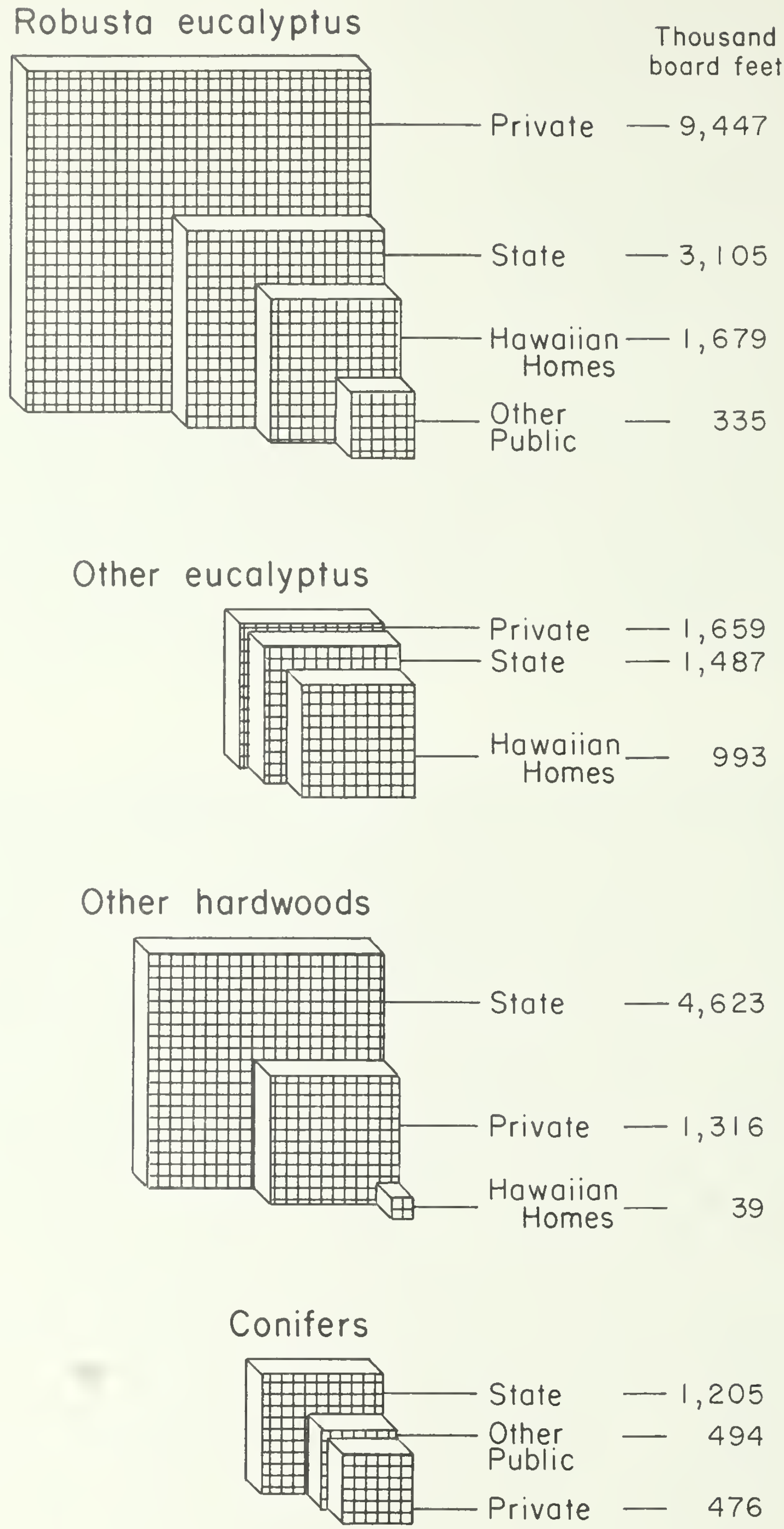


Figure 4.--*Sawtimber volume in planted stands by species group and ownership class, Island of Kauai, 1965.*

with higher yields. Private ownership totals 48 percent, or almost 13 million board feet, of the sawtimber volume; the State owns 39 percent or 10-1/2 million board feet. Hawaiian Homes owns almost 3 million board feet. Nearly 1 million board feet are in county and municipal ownership.

Age of Stands

Only about 550 acres of the commercial plantation timber stands are more than 40 years old (table 4). Practically all of the older stands are in the southeast part of the Island. Stands planted from 1926 to 1945 total more than 1,400 acres. Much of this acreage was planted between 1935 and 1941 by the Civilian Conservation Corps. Since 1945 nearly 1,500 acres of commercial plantations have been established. By far the greater part of these recent plantings has been done by the State Division of Forestry in the Kokee Reforestation Plantings.

Stand Yields

The average yield of sawtimber in planted sawtimber stands on Kauai is just over 14,000 board feet per acre. But yields vary greatly with stand age, species, site, history and condition of stand, and other factors. In general, the volumes in the better robusta eucalyptus and saligna eucalyptus stands more than 35 years old range from 30,000 to 40,000 board feet per acre. Most other hardwood species have lower yields. The highest stand average net volume measured was 69,000 board feet per acre in a Norfolk-Island-pine stand.

Timber Quality

Judged by log grades, Molucca albizzia is considered to be of better quality than other species (table 9); 59 percent of its sawtimber volume is in grades 1 and 2 factory lumber logs. Saligna, generally one of the eucalyptus species with higher log grades, has 53 percent of the volume in grades 1 and 2. Only 33 percent of the robusta eucalyptus is in grade 1 and 2 logs. Conifer species were not log-graded.

Opportunity for Industrial Development

Forests are a major feature of the Island of Kauai. Nearly two-thirds of the land, or about 220,000 acres, supports some kind of forest growth.[4] A large part of this is noncommercial forest land, but some 137,000 acres are commercial forest land that can produce crops of timber.

Most of the native forests are of particularly poor quality, often just brush. Thus, these poorly stocked or nonstocked native forests yield only small amounts of merchantable timber. The total volume of sawtimber in nearly 140,000 acres of native forests amounts to only 16 million board feet.

---

[4] Nelson and Wheeler. *Op. cit.*

Although continued small harvesting of fence posts, fuelwood, and miscellaneous products from native forests is likely, little acreage of the native stands offer prospects for sawtimber harvest.

Planted forests offer much better prospects. In contrast to the native forests, they have grown rapidly and now yield higher per-acre volumes of timber. In the slightly more than 1,900 acres of planted forests now grown to sawtimber size, the volume totals nearly 27 million board feet of sawtimber. Most of the forestation that produced this new timber resource was not done to grow sawtimber. Instead, trees were planted to control erosion, improve watershed cover, and provide fuelwood. Therefore, species planted were not necessarily selected on the basis of wood quality, but on the basis of adaptability and rapid growth. *Eucalyptus robusta*--a good sawtimber species--was highly favored. And so were several species that now offer little or no potential for sawtimber, such as ironwoods (*Casuarina* spp.) and paper-bark (*Melaleuca leucadendron*).

The success of some of these early plantings demonstrates that timber production potentials are far greater than might be inferred from the data on present total sawtimber volumes on this Island. We know that many valuable exotic timber species are adapted to the different forest sites. Timber yields can be prodigious. Under management, an average annual sawtimber growth rate of 1,000 board feet per acre can be expected from well-stocked forests on good sites.

Although its potential is limited, a small sawmilling industry conceivably could be based on the present timber resource. Such an industry would depend on the development of markets for the small volumes of specialized products for which the timber is useful. And it could only operate on a small scale or for a very few years.

There is, however, a potential to develop a much larger timber resource, an ample base for a significant large local milling industry. If only 20 percent of the 137,000 acres of presently little-used and unmanaged commercial forest land were planted to introduced species and managed, timber production would amount to more than 25 million board feet annually in about 30 years.

Recent forestation efforts by the State and to a much smaller extent by some private landowners are trying to capitalize on this potential. Species are being selected with consideration for wood qualities and adaptability to specific sites. Plantings are made in large blocks on lands where native forests are of particularly poor quality.

Since 1960, about 1,400 acres of land on Kauai have been reforested by the State Division of Forestry. This reforestation effort is being continued and should be expanded to bring a much greater forest area under management. The amount of reforestation accomplished during the next 10 years will determine in large part the amount of harvestable timber that might be available 30 to 40 years from now as a base for an economic industry.

Much of the native forest on Kauai is scrubby koa and ohia. Conversion of such types to planted forests can increase the timber resource and improve recreation and watershed values.

Slash and loblolly pines can be planted on the dry, eroding ridges below Kokee to improve watershed conditions. They also provide timber and improve recreation habitat.

Recreation Habitat and Watershed Protection

Forest plantations provide values besides timber. In fact, their value for watershed protection and for recreation use may exceed the value of timber harvests. Planted forests of introduced trees now provide the most attractive and heavily used forest recreation sites on the Island. Plantations established for watershed protection and erosion control have great value in improving esthetic values, on-site and from a distance. Planted forests can also provide improved wildlife habitat. Christmas trees can be produced in much greater numbers for local use or export.

These multiple benefits of planted forests accrue continuously year after year. In addition, periodic harvests of timber can be made without detracting from these recreation and watershed values. Public land managers and private owners, too, should take steps to develop all the potential benefits latent in these lands by improving the forests for timber production, recreation use, watershed protection, and wildlife habitat. It has been amply demonstrated on a small scale in the existing plantations that reforestation can enhance all these values.

Appendix

Definitions

Commercial and Noncommercial

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground.

> *Commercial forest land:* Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.
>
> *Noncommercial forest land:* (a) *Productive-reserved* forest land withdrawn from timber use through statute or administrative regulation, and (b) *unproductive* forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of the growing space is occupied by planted trees (exotic species in this report), regardless of native species predominance.

> *Commercial forest plantation:* A plantation of commercial tree species on commercial forest land.

Noncommercial forest plantation: A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuelwood or fence posts are excluded. The following were tallied on plots:

Scientific Name	*Common Name*
Acacia koa	koa
Acacia melanoxylon	blackwood acacia
Albizia falcata (A. moluccana)	Molucca albizzia
Araucaria cunninghamii	hoop-pine
Araucaria excelsa	Norfolk-Island-pine
Cryptomeria japonica	sugi
Eucalyptus citriodora	lemon eucalyptus
Eucalyptus microcorys	tallowwood eucalyptus
Eucalyptus paniculata	gray ironbark eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus resinifera	kinogum eucalyptus
Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus sideroxylon	red-ironbark eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Mangifera indica	mango
Metrosideros collina (M. polymorpha)	ohia
Sequoia sempervirens	redwood
Swietenia mahagoni	West Indies mahogany
Syncarpia glomulifera (S. laurifolia)	turpentine-tree
Tristania conferta	brushbox

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following were tallied on plots:

Scientific Name	*Common Name*
Aleurites moluccana	kukui (candlenut-tree)
Casuarina spp.	ironwoods
Eucalyptus sp.	unidentified eucalyptus
Eugenia cumini	Java-plum
Hibiscus tiliaceus	hau
Melaleuca leucadendron	paper-bark
Melia azedarach	pride-of-India
Melochia indica	melochia
Myrsine spp.	kolea

Hardwoods: Dicotyledonous trees; usually broadleaved.

Softwoods: Coniferous trees; usually evergreen; having needle or scale-like leaves.

Forest types: Forests which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type, ohia type, or tropical ash type. Otherwise they are designated:

> *Commercial eucalyptus type:* Planted stands predominantly of eucalyptus species, in which other hardwoods or conifers comprise less than 25 percent of the stand.
>
> *Commercial hardwood type:* Planted stands predominantly of hardwoods other than the eucalypts in which conifers or eucalypts comprise less than 25 percent of the stand.
>
> *Commercial conifer type:* Planted forests predominantly of conifers (e.g. Norfolk-Island-pine, sugi, pines, and redwood) in which eucalypts or other hardwoods comprise less than 25 percent of the stand.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

> *Sawtimber trees:* Live trees of commercial species of at least 11.0 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.
>
> *Poletimber trees:* Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.
>
> *Saplings and seedlings:* Live trees of commercial species between 1.0 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Merchantable sawtimber: Wood in trees defined as sawtimber trees.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections, V equals 0.905 $(0.22D^2 - 0.71D)$.

Sawtimber volume: The net volume of the saw-log portion of sawtimber trees, in board feet, International 1/4-inch rule.

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable sawlog cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5.0 inches d.b.h. or larger, from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches.

Stand-Class Sizes

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing-stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing-stock trees.

Nonstocked: Commercial forest lands less than 10 percent stocked with growing-stock trees.

Miscellaneous

Diameter breast height (d.b.h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as sawlogs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value of lumber the logs will yield. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[1] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, these are usually inherent in a species.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand by plantation stand. First, individual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured from the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared computer program. Tree measurements were converted to meaningful volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreage of the stand. The computer output consisted of tabular data for each stand and summaries of stand data by forest reserves. Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands and added to the computer processed data.

The accuracy goal for this inventory was ±20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. The reliability of estimates for each forest reserve, based on measured stands only, are shown below.

---

[1] U.S. Forest Products Laboratory. *Hardwood log grades for standard lumber--proposals and results.* U.S. Forest Serv. Forest Prod. Lab. Report 1737, 15 pp., illus. 1953.

Two chances out of three the estimated volume does not vary from the actual by greater than the sampling error indicated.

Forest Reserve	*Total volume* (M bd.ft.)	*Sampling error* (percent)
Halelea	109	13.6
Haupu	5,153	11.2
Lihue-Koloa	4,241	12.1
Moloaa	2,266	9.4
Na Pali-Kona	240	58.2
Nonou	1,723	15.2
Papapaholahola	799	16.2
Puu Ka Pele	3,985	16.8
Puu Ka Pele Park	282	9.6
Kokee Park	1,218	11.0
Waimea Canyon Park	78	60.1
Outside Forest Reserve	3,774	11.9

Table 1.--Area of forest plantations for all ownerships by forest type and forest reserve, Island of Kauai, 1965

Forest reserve	Forest type: Commercial eucalypts	Forest type: Other commercial hardwoods	Forest type: Commercial conifers	Total commercial types	Total noncommercial types	Total all types
	Acres					
Halelea	8	4	--	12	5	17
Haupu	278	11	--	289	63	352
Kalepa	80	20	19	119	47	166
Kealia	15	7	--	22	--	22
Lihue-Koloa	228	128	37	393	146	539
Moloaa	71	95	25	191	--	191
Na Pali-Kona	--	--	198	198	--	198
Nonou	131	137	14	282	15	297
Papapaholahola	16	--	10	26	3	29
Puu Ka Pele	520	9	861	1,390	17	1,407
Puu Ka Pele Park	34	--	60	94	--	94
Kokee Park	57	51	27	135	--	135
Waimea Canyon Park	7	8	--	15	--	15
Outside Reserve	253	5	--	258	274	532
Total	1,698	475	1,251	3,424	570	3,994

Table 2.--Area of forest plantations by ownership class,[1/] forest type and forest reserve, Island of Kauai, 1965

Forest reserve and ownership	Forest type: Commercial eucalypts	Forest type: Other commercial hardwoods	Forest type: Commercial conifers	Total commercial types	Total non-commercial types	Total all types
	Acres					
State:						
Halelea	8	4	--	12	5	17
Kalepa	54	20	19	93	6	99
Kealia	12	7	--	19	--	19
Lihue-Koloa	99	66	17	182	38	220
Moloaa	71	95	25	191	--	191
Na Pali-Kona	--	--	133	133	--	133
Nonou	131	137	14	282	15	297
Puu Ka Pele	103	2	336	441	6	447
Puu Ka Pele Park	34	--	60	94	--	94
Kokee Park	57	51	27	135	--	135
Waimea Canyon Park	7	6	--	13	--	13
Outside Reserve	--	--	--	--	12	12
Total	576	388	631	1,595	82	1,677
Hawaiian Homes:						
Na Pali-Kona	--	--	65	65	--	65
Puu Ka Pele	417	7	525	949	11	960
Waimea Canyon Park	--	2	--	2	--	2
Outside Reserve	6	--	--	6	--	6
Total	423	9	590	1,022	11	1,033
Private:						
Haupu	278	11	--	289	63	352
Kalepa	26	--	--	26	41	67
Kealia	3	--	--	3	--	3
Lihue-Koloa	129	62	20	211	108	319
Outside Reserve	247	5	--	252	262	514
Total	683	78	20	781	474	1,255
County and Municipal:						
Papapaholahola	16	--	10	26	3	29
Island total	1,698	475	1,251	3,424	570	3,994

[1/] Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand, the ownership designation may be in error, although over-all ownership statistics are probably not greatly affected by this kind of error.

Table 3.--Area of forest plantations by forest type, ownership class, and stand size class, Island of Kauai, 1965

Stand-size class and forest type	State	Hawaiian Homes	Other public	Private	All ownerships
	Acres				
Commercial types:					
Sawtimber stands					
Robusta eucalyptus	374	239	16	560	1,189
Saligna eucalyptus	36	16	--	--	52
Other eucalypts	29	88	--	81	198
Silk-oak	20	2	--	--	22
Molucca albizzia	205	--	--	69	274
Other hardwoods	67	--	--	5	72
Conifers	68	--	10	20	98
Total	799	345	26	735	1,905
Poletimber stands					
Robusta eucalyptus	--	--	--	4	4
Saligna eucalyptus	3	--	--	--	3
Other eucalypts	30	19	--	35	84
Silk-oak	12	7	--	--	19
Molucca albizzia	--	--	--	4	4
Other hardwoods	8	--	--	--	8
Conifers	3	--	--	--	3
Total	56	26	--	43	125
Seedling & sapling stands					
Saligna eucalyptus	46	52	--	--	98
Other eucalypts	58	9	--	3	70
Other hardwoods	76	--	--	--	76
Conifers	560	590	--	--	1,150
Total	740	651	--	3	1,394
Total commercial	1,595	1,022	26	781	3,424
Noncommercial types:					
Eucalyptus spp.	--	4	--	--	4
Casuarina spp.	21	7	--	358	386
Paper-bark	61	--	3	116	180
Total noncommercial	82	11	3	474	570
Total forest plantation	1,677	1,033	29	1,255	3,994

Table 4.--Area of forest plantations by forest type and period planted, Island of Kauai, 1965

Forest type	Period of planting						Total
	1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1965	
	Acres						
Robusta eucalyptus	90	279	266	554	4	--	1,193
Saligna eucalyptus	--	--	--	52	3	98	153
Other eucalypts	3	68	21	137	56	67	352
Silk-oak	--	--	18	23	--	--	41
Albizzia	--	94	139	41	4	--	278
Other hardwoods	--	--	36	36	8	76	156
Commercial conifers	--	18	42	41	--	1,150	1,251
Noncommercial	8	204	283	69	6	--	570
Total	101	663	805	953	81	1,391	3,994

Table 5.--Volume of growing stock and sawtimber, by species, in planted sawtimber stands, Island of Kauai, 1965

Species	Growing stock	Sawtimber
	Thousand cubic feet	Thousand board feet
Blackbutt eucalyptus	39	213
Blackwood acacia	75	381
Brushbox	30	63
Eucalyptus spp.	209	935
Gray ironbark eucalyptus	82	246
Hoop pine	9	14
Kinogum eucalyptus	62	372
Koa	15	50
Lemon eucalyptus	87	418
West Indies mahogany	1	1
Molucca albizzia	905	5,130
Norfolk-Island-pine	318	1,538
Ohia	11	42
Red-ironbark eucalyptus	18	45
Redwood	42	233
Robusta eucalyptus	3,328	14,566
Saligna eucalyptus	267	1,651
Silk-oak	83	342
Sugi	83	390
Tallowwood eucalyptus	39	192
Tropical ash	10	32
Turpentine-tree	5	4
Total	5,718	26,858

Table 6.--Volume (in thousands of feet) of growing stock and sawtimber in planted sawtimber stands by ownership class[1] and species group, Island of Kauai, 1965

Species group	State		Hawaiian Homes		Private		County & municipal		All ownerships	
	Growing stock	Sawtimber	Growing stock	Sawtimber	Growing stock	Sawtimber	Growing stock	Sawtimber	Growing stock	Sawtimber
	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]	Cu.ft.	Bd.ft.[2]
Robusta eucalyptus	739	3,105	469	1,679	2,052	9,447	68	335	3,328	14,566
Saligna eucalyptus	179	1,121	88	530	--	--	--	--	267	1,651
Other eucalypts[3]	92	366	148	463	331	1,659	--	--	571	2,488
Silk-oak	46	173	9	29	27	140	1	--	83	342
Molucca albizzia	695	3,976	--	--	210	1,154	--	--	905	5,130
Other hardwoods[4]	102	474	3	10	7	22	--	--	112	506
Conifers[5]	255	1,205	--	--	103	476	94	494	452	2,175
Total	2,108	10,420	717	2,711	2,730	12,898	163	829	5,718	26,858

1/ See footnote 1, Table 2.
2/ International 1/4-inch rule.
3/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
4/ Includes blackwood acacia, tropical ash, koa, ohia, and West Indies mahogany.
5/ Includes Norfolk-Island-pine, hoop-pine, redwood, and sugi.

Table 7.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and diameter class, Island of Kauai, 1965

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
	Thousand board feet[1]								
Robusta eucalyptus	14,566	--	1,506	2,145	2,405	2,637	5,239	613	21
Saligna eucalyptus	1,651	--	21	42	146	207	1,219	16	--
Other eucalypts[2]	2,488	--	208	394	375	405	947	146	13
Silk-oak	342	--	73	68	53	63	85	--	--
Molucca albizzia	5,130	--	84	284	477	685	2,370	901	329
Other hardwoods[3]	506	--	42	61	63	56	67	217	--
Conifers[4]	2,175	--	169	226	487	433	842	18	--
Total	26,858	--	2,103	3,220	4,006	4,486	10,769	1,911	363
	Thousand cubic feet								
Robusta eucalyptus	3,328	261	539	536	489	496	910	94	3
Saligna eucalyptus	267	2	7	9	27	34	185	3	--
Other eucalypts[2]	571	73	77	90	76	71	160	22	2
Silk-oak	83	13	23	16	8	9	14	--	--
Molucca albizzia	905	29	26	55	85	116	390	146	58
Other hardwoods[3]	112	9	17	14	13	11	46	2	--
Conifers[4]	452	38	51	50	87	83	140	3	--
Total	5,718	425	740	770	785	820	1,845	270	63

1/ International 1/4-inch rule.
2/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
3/ Includes blackwood acacia, koa, West Indies mahogany, ohia, and tropical ash.
4/ Includes Norfolk-Island-pine, hoop-pine, redwood, and sugi.

Table 8.--Volume of cull trees in planted sawtimber stands by forest reserve and species group, Island of Kauai, 1965

Forest reserve	Robusta eucalyptus	Saligna eucalyptus	Other eucalypts 1/	Silk-oak	Albizzia	Other hardwoods 2/	Commercial conifers 3/	Noncommercial species 4/	All species
	Thousand cubic feet								
Halelea	1	--	--	--	1	--	--	--	2
Haupu	58	--	3	--	1	--	--	98	160
Kalepa	--	--	--	--	--	--	--	--	--
Kealia	1	--	--	--	--	--	--	--	1
Lihue-Koloa	30	--	4	1	4	3	2	58	102
Moloaa	--	--	--	--	2	--	--	5	7
Na Pali-Kona	--	--	--	--	--	--	--	1	1
Nonou	7	--	1	2	4	3	1	36	54
Papapaholahola	5	--	--	1	--	--	1	--	7
Puu Ka Pele	28	2	8	2	--	4	--	3	47
Puu Ka Pele Park	4	--	1	--	--	--	--	--	5
Kokee Park	5	--	1	--	--	6	2	--	14
Waimea Canyon Park	--	--	1	1	--	--	--	--	2
Outside Reserve	36	--	4	--	--	--	--	48	88
Total	175	2	23	7	12	16	6	249	490

1/ Mainly Eucalyptus spp. but includes brushbox and turpentine-tree.
2/ Includes blackwood acacia, tropical ash, koa, ohia, and West Indies mahogany.
3/ Includes Norfolk-Island-pine, hoop-pine, redwood, and sugi.
4/ Includes Casuarina spp., paper-bark, kukui, hau, Java plum, melochia, kolea, mango, and Pride-of-India.

Table 9.--Sawtimber volume in planted sawtimber stands by ownership class, species group, and log grade,[1] Island of Kauai, 1965

Ownership class and species group	All grades	Factory lumber logs: Grade 1	Factory lumber logs: Grade 2	Factory lumber logs: Grade 3	Tie and timber logs: Grade 4	Softwood species[2]
	Thousand board feet[3]					
State:						
Robusta eucalyptus	3,105	462	313	653	1,677	--
Saligna eucalyptus	1,121	357	263	286	215	--
Other eucalypts[4]	366	65	62	79	160	--
Silk-oak	173	11	--	19	143	--
Tropical ash	11	--	--	3	8	--
Albizzia	3,976	1,649	698	889	740	--
Other hardwoods[5]	463	81	71	122	189	--
Commercial conifers[6]	1,205	--	--	--	--	1,205
Total	10,420	2,625	1,407	2,051	3,132	1,205
Hawaiian Homes:						
Robusta eucalyptus	1,679	47	54	255	1,323	--
Saligna eucalyptus	530	98	152	153	127	--
Other eucalypts[4]	463	--	16	145	302	--
Silk-oak	29	--	--	11	18	--
Other hardwoods[5]	10	--	--	2	8	--
Total	2,711	145	222	566	1,778	--
Private:						
Robusta eucalyptus	9,447	2,205	1,562	1,831	3,849	--
Other eucalypts[4]	1,659	495	281	302	581	--
Silk-oak	140	44	33	37	26	--
Tropical ash	21	--	--	6	15	--
Albizzia	1,154	474	196	265	219	--
Other hardwoods[5]	1	--	--	--	1	
Commercial conifers[6]	476	--	--	--	--	476
Total	12,898	3,218	2,072	2,441	4,691	476
County and Municipal:						
Robusta eucalyptus	335	119	70	61	85	--
Commercial conifers[6]	494	--	--	--	--	494
Total	829	119	70	61	85	494
All Ownerships:						
Robusta eucalyptus	14,566	2,833	1,999	2,800	6,934	--
Saligna eucalyptus	1,651	455	415	439	342	--
Other eucalypts[4]	2,488	560	359	526	1,043	--
Silk-oak	342	55	33	67	187	--
Tropical ash	32	--	--	9	23	--
Albizzia	5,130	2,123	894	1,154	959	--
Other hardwoods[5]	474	81	71	124	198	--
Commercial conifers[6]	2,175	--	--	--	--	2,175
Total	26,858	6,107	3,771	5,119	9,686	2,175

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ Commercial conifer species are not log-graded.
3/ International 1/4-inch rule.
4/ Mainly *Eucalyptus* spp. but includes brushbox and turpentine-tree.
5/ Includes blackwood acacia, koa, West Indies mahogany, ohia, and tropical ash.
6/ Includes Norfolk-Island-pine, hoop-pine, redwood, and sugi.

Table 10.--Listing of individual stands and plantings with species type, ownership, area, and volume, Island of Kauai, 1966

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner[1/]	Acres	Total stand volume
				Thousand board feet
2001	Gray ironbark eucalyptus	111	4	19
2002	Red-ironbark eucalyptus	111	5	20
2003	Gray ironbark eucalyptus	111	9	43
2004	Mixed eucalyptus	111	12	42
2005	Robusta eucalyptus	111	40	118
2006	Robusta eucalyptus	111	30	109
2007	" "	112	2	6
2008	" "	112	7	7
2009	" "	112	7	23
2010	" "	112	4	12
2011	Robusta eucalyptus	112	7	21
2012	" "	112	27	195
2013	" "	111	9	37
2014	Brushbox	112	2	(2/)
2015	Robusta eucalyptus	112	2	6
2016	Robusta eucalyptus	112	2	6
2017	" "	112	2	6
2018	" "	112	3	9
2019	Brushbox	112	5	42
2020	Saligna eucalyptus	112	18	531
2021	Robusta eucalyptus	112	18	161
2022	" "	112	2	6
2023	" "	112	2	6
2024	Brushbox	111	9	(2/)
2025	Saligna eucalyptus	111	16	595
2026	Robusta eucalyptus	111	31	214
2027	" "	111	38	337
2028	Blackwood acacia	112	8	(2/)
2029	Robusta eucalyptus	112	2	23
2030	Blackwood acacia	112	5	64

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2031	Silk-oak	112	2	9
2032	" "	112	2	9
2033	" "	112	2	9
2034	" "	112	4	18
2035	Robusta eucalyptus	112	7	42
2036	Robusta eucalyptus	112	7	79
2037	" "	112	14	121
2038	" "	111	45	470
2039	" "	111	4	12
2040	Silk-oak	111	2	9
2041	Silk-oak	112	4	18
2042	" "	111	3	(2/)
2043	Gray ironbark	111	4	19
2044	" "	111	2	10
2045	Mixed eucalyptus	112	7	78
2046	Silk-oak	112	2	9
2047	" "	112	2	9
2048	Gray ironbark	111	24	31
2049	Tallowwood eucalyptus	111	8	54
2050	Mixed eucalyptus	111	7	69
2051	Robusta eucalyptus	111	13	66
2052	Ironwood	808	16	(3/)
2053	"	809	6	(3/)
2054	Robusta eucalyptus	236	4	55
2055	Molucca albizzia	236	8	169
2056	Molucca albizzia	112	7	156
2057	Brushbox	236	9	(2/)
2058	Norfolk-Island-pine	236	4	140
2059	Paper-bark	236	18	(3/)
2060	Molucca albizzia	236	7	122
2061	Robusta eucalyptus	236	5	75
2062	Mixed species	236	5	29
2063	Paper-bark	236	4	(3/)
2064	Molucca albizzia	236	4	89
2065	" "	112	29	533

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2066	Norfolk-Island-pine	112	3	105
2067	Molucca albizzia	236	27	626
2068	Norfolk-Island-pine	119	7	483
2069	Paper-bark	119	3	(3/)
2070	Robusta eucalyptus	119	16	316
2071	Norfolk-Island-pine	119	3	30
2072	" " "	112	8	280
2073	Robusta eucalyptus	112	3	42
2074	Paper-bark	112	3	(3/)
2075	Hoop-pine	112	4	14
2076	Mixed eucalyptus	214	48	518
2077	Molucca albizzia	141	9	163
2078	Robusta eucalyptus	141	7	110
2079	" "	141	2	28
2080	Molucca albizzia	141	3	54
2081	Paper-bark	141	16	(3/)
2082	Robusta eucalyptus	801	4	24
2083	Brushbox	139	9	(2/)
2084	Robusta eucalyptus	801	24	681
2085	" "	141	2	20
2086	Robusta eucalyptus	141	15	148
2087	" "	141	3	42
2088	" "	141	16	214
2089	Norfolk-Island-pine	141	3	35
2090	Robusta eucalyptus	112	5	109
2091	Norfolk-Island-pine	230	3	35
2092	Robusta eucalyptus	236	4	55
2093	" "	236	4	(2/)
2094	Paper-bark	112	2	(3/)
2095	Norfolk-Island-pine	141	4	47
2096	Brushbox	141	3	25
2097	Norfolk-Island-pine	112	2	23
2098	Paper-bark	141	13	(3/)
2099	" "	141	7	(3/)
2100	Turpentine-tree	112	4	4

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2101	Paper-bark	141	14	(3/)
2102	Ironwood	141	23	(3/)
2103	Norfolk-Island-pine	141	3	35
2104	" " "	141	3	35
2105	Brushbox	141	7	(2/)
2106	Robusta eucalyptus	141	28	773
2107	Mixed eucalyptus	236	11	101
2108	Lemon eucalyptus	236	3	75
2109	Mixed eucalyptus	236	5	124
2110	Robusta eucalyptus	236	8	131
2111	Paper-bark	112	12	(3/)
2112	Robusta eucalyptus	112	4	12
2113	" "	214	2	28
2114	" "	214	3	42
2115	Mixed eucalyptus	214	4	43
2116	Robusta eucalyptus	801	32	978
2117	" "	214	2	39
2118	" "	214	6	117
2119	" "	214	4	78
2120	Mixed eucalyptus	111	4	(2/)
2121	Molucca albizzia	214	11	205
2122	Paper-bark	214	5	(3/)
2123	Ironwood	214	15	(3/)
2124	Robusta eucalyptus	214	12	186
2125	" "	214	10	23
2126	Robusta eucalyptus	214	3	7
4/ 2132	Robusta eucalyptus	246	20	385
2133	" "	246	4	77
2134	" "	214	3	34
2135	Robusta eucalyptus	214	14	434
2136	" "	214	6	247
2137	" "	214	13	231
2138	" "	214	3	34
2139	Ironwood	214	8	(3/)

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2140	Mixed eucalyptus	214	3	34
2141	Robusta eucalyptus	214	3	42
2142	" "	214	33	378
2143	" "	214	5	188
2144	Ironwood	214	8	(3/)
2145	Ironwood	214	8	(3/)
2146	"	214	20	(3/)
2147	"	214	5	(3/)
2148	Robusta eucalyptus	214	23	349
2149	" "	214	16	204
2150	Robusta eucalyptus	214	4	61
2151	" "	801	38	573
2152	Ironwood	801	30	(3/)
2153	Robusta eucalyptus	801	64	1,542
2154	Ironwood	801	8	(3/)
2155	Robusta eucalyptus	801	62	656
5/ 2158	Brushbox	112	11	1
5/ 2160	Molucca albizzia	112	68	2,265
2161	Robusta eucalyptus	111	6	91
2162	" "	139	3	46
2163	Molucca albizzia	112	2	21
2164	Norfolk-Island-pine	112	4	47
2165	" " "	112	6	70
2166	Ironwood	233	67	(3/)
2167	"	214	13	(3/)
2168	Robusta eucalyptus	214	4	46
2169	Ironwood	233	13	(3/)
2170	"	801	10	(3/)
2171	Ironwood	803	6	(3/)
2172	Robusta eucalyptus	112	36	457
2173	Molucca albizzia	112	4	89
2174	Robusta eucalyptus	233	25	556
2175	Ironwood	233	6	(3/)

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2176	Ironwood	233	6	(3/)
2177	Molucca albizzia	112	4	89
2178	Paper-bark	233	12	(3/)
2179	" "	233	3	(3/)
2180	Robusta eucalyptus	112	4	24
2181	Molucca albizzia	112	13	138
2182	Ironwood	112	7	(3/)
2183	Robusta eucalyptus	112	24	349
2184	Ironwood	112	8	(3/)
2185	Robusta eucalyptus	112	36	216
2186	Molucca albizzia	112	6	94
2187	Mixed eucalyptus	139	4	(2/)
2188	Brushbox	139	7	(2/)
2189	Ironwood	233	7	(3/)
2190	Red-ironbark eucalyptus	111	5	16
2191	Saligna eucalyptus	112	18	664
2192	Silk-oak	111	2	(2/)
2193	" "	111	2	(2/)
2194	Red-ironbark eucalyptus	111	3	10
2195	Ironwood	111	7	(3/)
2196	Robusta eucalyptus	111	23	280
2197	Paper-bark	214	19	(3/)
2198	" "	214	2	(3/)
2199	Robusta eucalyptus	214	2	28
2200	Ironwood	214	7	(3/)
2201	Ironwood	214	4	(3/)
2202	Robusta eucalyptus	214	3	34
2203	Brushbox	112	5	(2/)
2204	Paper-bark	112	6	(3/)
2205	Robusta eucalyptus	112	4	60
2206	Robusta eucalyptus	112	25	345
2207	" "	112	3	34
2208	" "	112	10	158
2209	Mixed eucalyptus	112	2	22
2210	Blackwood acacia	112	23	293

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2211	Robusta eucalyptus	112	4	45
2212	" "	112	12	152
2213	Silk-oak	112	2	9
2214	Sugi	112	3	(2/)
2215	"	112	10	240
2216	Robusta eucalyptus	112	5	86
2217	Sugi	112	10	124
2218	"	112	11	47
2219	Redwood	112	6	237
2220	Paper-bark	112	30	(3/)
2221	Robusta eucalyptus	112	8	71
2222	" "	112	58	174
2223	Norfolk-Island-pine	112	4	47
2224	Mixed species	112	36	110
2225	Molucca albizzia	112	20	161
2226	Robusta eucalyptus	112	3	18
2227	Gray ironbark eucalyptus	112	2	9
2228	Robusta eucalyptus	112	4	24
2229	Molucca albizzia	112	48	411
2230	Silk-oak	112	12	(2/)
2231	Gray ironbark eucalyptus	112	2	(2/)
2232	Brushbox	112	6	(2/)
2233	Ironwood	139	41	(3/)
2234	Eucalyptus species	139	3	18
2235	Robusta eucalyptus	141	4	39
2236	Ironwood	141	10	(3/)
2237	Robusta eucalyptus	141	4	39
2238	Molucca albizzia	141	4	(2/)
2239	Ironwood	236	9	(3/)
2240	"	803	6	(3/)
2241	Turpentine-tree	112	2	(2/)
2242	Robusta eucalyptus	112	3	66
2243	Molucca albizzia	112	4	32
2244	Robusta eucalyptus	141	4	39
2245	" "	112	4	55

See footnotes at end of Table.

Table 10, continued

FORESTS PLANTED BEFORE 1957

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
2246	Robusta eucalyptus	112	4	55
2247	Paper-bark	236	3	(3/)
2248	" "	112	3	(3/)
2249	Gray ironbark eucalyptus	111	10	(2/)
2250	Eucalyptus species	112	3	9
2251	Brushbox	112	2	(2/)
2252	Blackwood acacia	112	3	38
2253	Robusta eucalyptus	214	4	61
2254	Ironwood	801	6	(3/)
2255	"	112	6	(3/)
2256	Paper-bark	112	5	(3/)
2257	Brushbox	139	3	(2/)
2258	"	112	3	(2/)
2259	"	112	3	(2/)
2260	Turpentine-tree	112	3	(2/)
2261	Saligna eucalyptus	112	3	(2/)
2262	Brushbox	112	2	(2/)
	Total Forest Plantation	--	2,603	26,858

AREAS REFORESTED 1957-65[6/]

Stand no.	Species type	Owner	Acres	Total stand volume
	Kokee area:			
--	Saligna eucalyptus	111	52	(2/)
--	Mixed eucalyptus	111	9	(2/)
--	Pines	111	590	(2/)
--	Pines	112	516	(2/)
	Total Kokee	--	1,167	--
	Kalepa area:			
--	Mixed eucalyptus	112	25	(2/)
--	Mixed species	112	20	(2/)
--	Pines	112	19	(2/)
	Total Kalepa	--	64	--

See footnotes at end of Table.

Table 10, continued

AREAS REFORESTED 1957-65 6/

Stand no.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
	Lihue-Koloa area:			
--	Saligna eucalyptus	112	8	(2/)
--	Mixed eucalyptus	112	13	(2/)
--	Mixed species	112	29	(2/)
	Total Lihue-Koloa	--	50	--
	Moloaa area:			
--	Saligna eucalyptus	112	40	(2/)
--	Mixed eucalyptus	112	20	(2/)
--	Mixed species	112	25	(2/)
--	Norfolk-Island-pine	112	25	(2/)
	Total Moloaa	--	110	--
	Total reforestation area	--	1,391	--
	Total all forest plantations	--	3,994	--

1/ Code number used:
111 = owned by Hawaiian Homes Commission
112 = owned by State of Hawaii
119 = owned by County and Municipal Governments
All other numbers = privately owned.

2/ Poletimber or seedling and sapling stands.

3/ Noncommercial plantation type.

4/ Stand Numbers 2127-31 not used.

5/ Stand Numbers 2156, 2157, and 2159 not used.

6/ No stand numbers assigned.

Table 11.--Identity of individual plantation stands in the groups shown on the map "Forest Plantations on the Island of Kauai--1965"[1/]

Group stand no.	Individual stand no.	Group stand no.	Individual stand no.
1	2054-75, 92-94, 97, 2100,72-73, 77, 2205-06, 45-48	21	2111-12, 2220-21
		22	2222-27
2	2088-89	23	2163-65, 80-86, 2228-30
3	2077-81, 85-87, 95-96, 98-99, 2101, 04-05, 2238, 44	24	2178-79
		25	2175-76
4	2102-03, 2235-37		
5	2107-10, 2239	26	2174
		27	2161-62
6	2091	28	2132-33, 58, 60, 71, 2240
7	2113-14, 41	29	2052-53, 90, 2242-43, 56
8	2197	30	2028-29, 2210, 13-19, 52
9	2106		
10	2117-19, 21-26	31	2033-36, 2207-09, 11-12, 50-51
		32	2030-32
11	2076, 2115-16, 55, 2254	33	2008-12
12	2146-50, 2201, 53	34	2001-02, 06-07, 2190, 94
13	2198-99, 2200, 02	35	2003, 13, 2120
14	2082, 84, 2151-54, 70		
15	2138-40, 42-45	36	2014-18
		37	2022, 2192
16	2134-37, 66-69	38	2004-05, 23, 2193
17	2189	39	2019-21, 24-27, 37-41, 2191, 95-96, 2255
18	2233-34		
19	2083, 2187-88, 2241, 57-62	40	2042-51, 2249
20	2203-04, 31-32		

1/ Unnumbered stands on the map are identified by symbols as follows:

KORP--Kokee reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

KARP--Kalepa reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

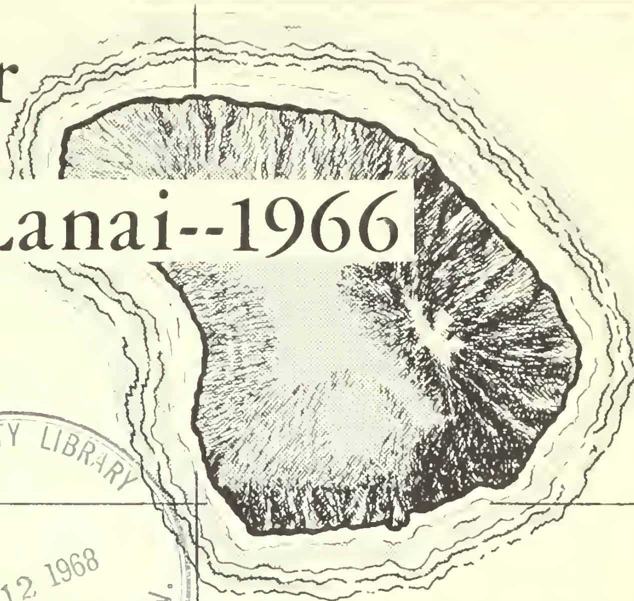
LKRP--Lihue-Koloa reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

MRP --Moloaa reforestation planting, 1957-65; includes seedling, sapling, and pole timber.

See table 10.

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 7 1967

Plantation Timber on the Island of Lanai--1966



Wesley H. C. Wong, Jr.
Nobuo Honda
Robert E. Nelson

Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California 94701

and

Division of Forestry, Department of Land and Natural Resources, State of Hawaii, Honolulu, Hawaii 96813

Foreword

This report is one of a series about planted timber on the major islands in the State of Hawaii. Reports for the islands of Hawaii (1965) and Kauai (1967) have been published. Summarized here are the results of an inventory of timber in planted forests on the island of Lanai. This inventory supplements the initial Forest Survey of the State completed in 1963. That survey indicated the importance of planted forests as a timber resource but provided no details. This bulletin reports: (a) location and acreage of each planted stand, (b) species composition and age, (c) timber volume and quality, and (d) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, in charge of the Station's forestry research in Hawaii. Nobuo Honda, forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory and supervised the field work.

Many individuals aided in various phases of the survey. Special acknowledgment is due the field crew: Forester Wesley Wong, Jr., of the Hawaii Division of Forestry, assisted by William Kwon of the Hawaii Division of Fish and Game.

E. M. Hornibrook, retired, formerly in charge of Forest Survey at the Pacific Southwest Station, and Russell K. LeBarron, formerly forest ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, systems analyst, Pacific Southwest Station, developed specifications for processing the data by electronic computers. The Computing Center at the University of Hawaii processed the data.

Generous cooperation in the survey was provided by Floyd M. Cossitt, acting State forester (retired), Max F. Landgraf, State Forester (retired), and Karl H. Korte, district forester, and personnel of Dole Pineapple Company.

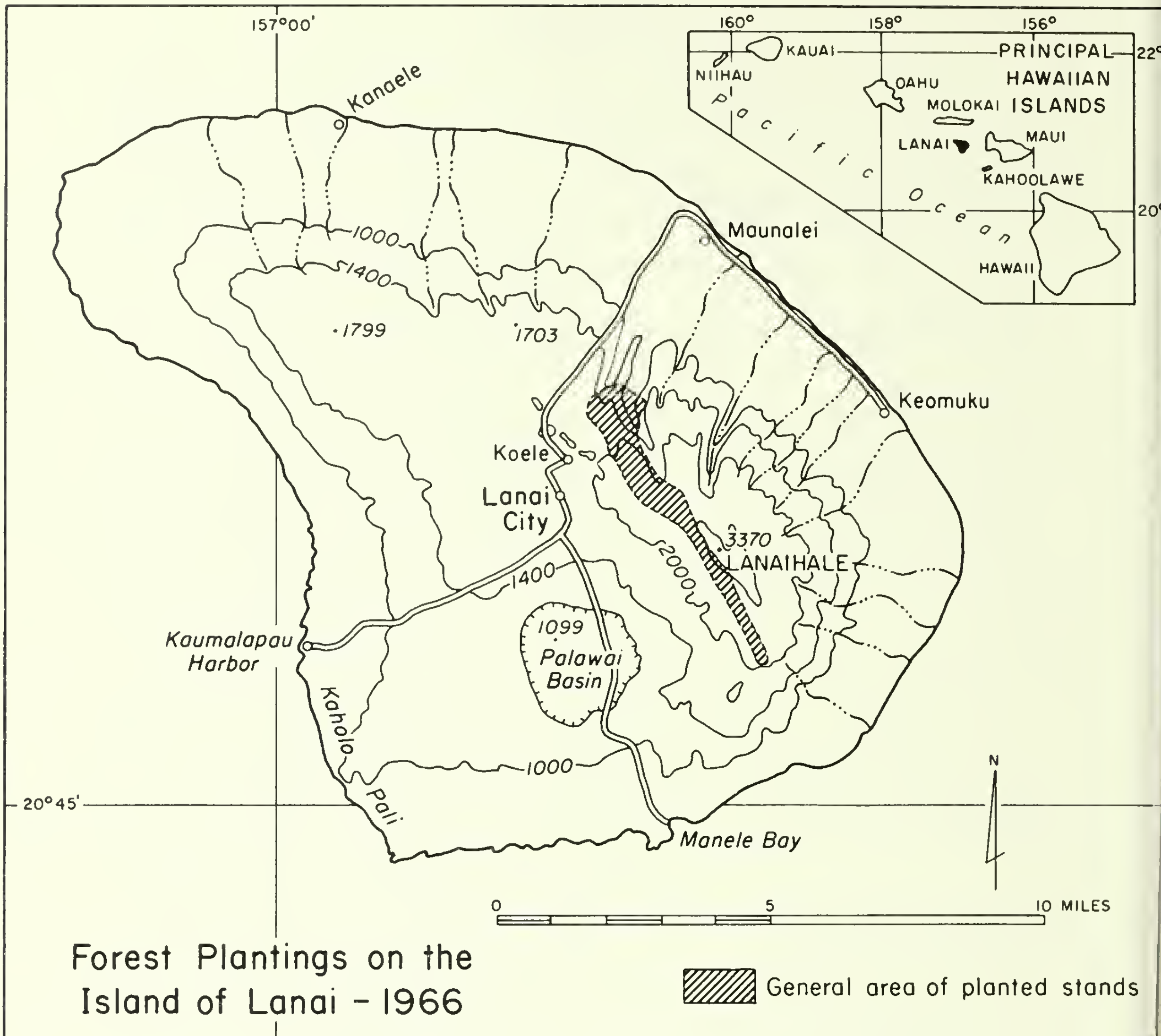
COVER PHOTO: *This Blackbutt Eucalyptus stand yields about 20,000 board feet per acre--the highest volume per acre on the Island of Lanai.*

OXFORD: (969):524.61:228.7. RETRIEVAL TERMS: planted forests; timber inventory; Forest Survey; plantations; Lanai; Hawaii.

Contents

The Authors

WESLEY H. C. WONG, JR., a native of Wailuku, Maui, received his bachelor's degree in forestry from Oregon State University in 1964. He joined the Hawaii Division of Forestry in August 1964 and has been primarily responsible for gathering field data for the forest inventory. NOBUO HONDA, a native of Kona, Hawaii, received his bachelor's degree in forestry from Humboldt State College in 1960. As timber survey forester for the Hawaii Division of Forestry since April 1960, he has been assigned primarily to the forest inventory of the State. ROBERT E. NELSON has been in charge of the Station's forestry research in Hawaii, with headquarters in Honolulu since 1957. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949.



Forest Plantings on the Island of Lanai - 1966

The Island of Lanai is one of the smaller islands in the Hawaiian chain. Located almost in the middle of the chain, it is 17 miles long and 13 miles wide. Of volcanic origin, the island rises rather steeply out of the ocean. Rugged topography marks the coastline, especially on the southern and western shores where sheer cliffs meet the sea. A large arable central plateau, or volcanic crater basin, lies at 1,500 to 2,000 feet elevation. This plateau is bounded on the east by rugged Lanaihale, which rises to 3,370 feet elevation.

Much of the land is arid, with annual rainfall ranging from less than 20 inches along the shoreline to about 40 inches at the summit of Lanaihale. Water is limited on Lanai. A critically important watershed is the central mountain--the only source of irrigation and domestic water.

There are large areas of grassland, usually sparsely covered, with much bare soil exposed most of the year (fig. 1). And the Island also has sizeable areas of barren eroded lands, rocklands, and steep pali.

Except for a few small parcels of land in houselots and government administrative sites, the total land area of 90,000 acres (641 square miles) is owned by the Dole Pineapple Company. Of this acreage, about 17,000 acres in the central plain are cultivated for pineapple production--the only significant commercial activity offering employment for residents on the island. Fishing, seasonal hunting, and tourist services offer additional but minor employment. There is no livestock industry on this island.

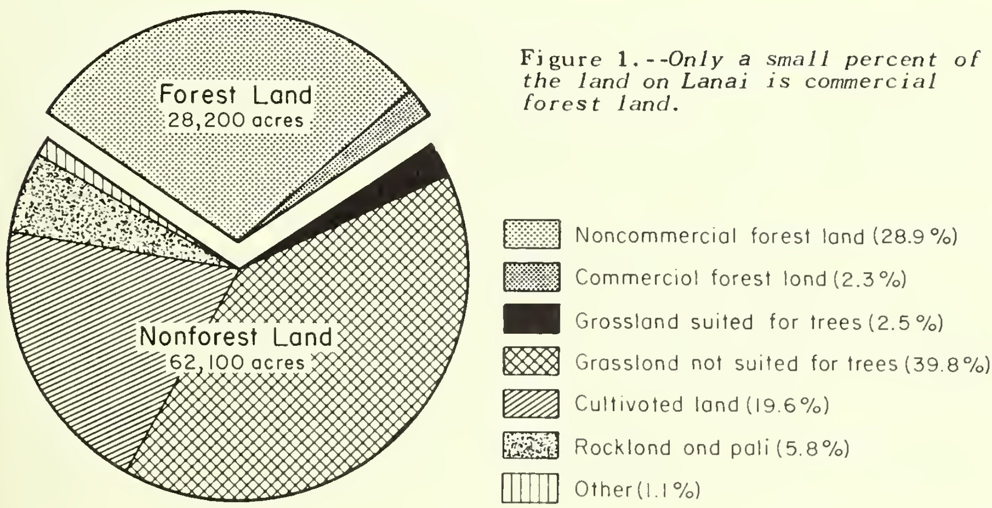


Figure 1.--*Only a small percent of the land on Lanai is commercial forest land.*

The first forest inventory in Hawaii showed that about 30 percent of the Island of Lanai--28,200 acres--is forest land[1] (fig. 1). But most of this amount--some 26,000 acres--is noncommercial forest land mainly in the lower, dry areas where kiawe (*Prosopis pallida*) and other brushy forest types predominate. Only about 2,000 acres are considered commercial forest land. They lie on the slopes of the central mountain where soils and rainfall can support timber growth. The native forests do not include sawtimber stands,[2] but some of the planted forests have developed into excellent timber stands.

No land is now in Forest Reserve status[3] on Lanai. But from 1941 to 1957, the central mountain was a Forest Reserve.

Tree planting was started on Lanai more than 40 years ago by the Lanai Company, Ltd. for several purposes: windbreaks, fence posts, fuel, and watershed improvement. The latter was done mainly to prevent erosion, induce rainfall, and moderate runoff. Although the total acreage of forest plantings is small, some of the planted areas have developed into valuable forests for watershed protection, recreation, game habitat, and wood products. We have made a stand-by-stand inventory to obtain information about plantation forest acreage, species, timber volume, and quality. This report summarizes data compiled for each plantation stand.

Plantation Timber Resource

Area

Most forest planting on the Island of Lanai has been on the slopes of Lanaihale (see map). Commercial forest plantations[4] total only about 400 acres in stands 2 acres and larger. Of this amount, about 325 acres are sawtimber stands (table 1), 70 acres are sapling and pole-size pine stands, and about 75 acres are noncommercial plantations.

Eucalypts make up more than 80 percent of the area of sawtimber stands (table 1). There are some 150 acres of robusta eucalyptus sawtimber stands, for this species was heavily favored in early plantings. Other hardwoods, such as molucca albizzia, tropical ash, and Australian redcedar, together with Norfolk-Island-pine, total less than 20 percent of the acreage of sawtimber stands.

---

[1]Nelson, Robert E. and Wheeler, Philip R. *Forest Resources of Hawaii, 1961.* Forestry Div., Dep. Land and Nat. Res., State of Hawaii, in cooperation with the Pacific SW. Forest and Range Exp. Sta., Forest Serv., U.S. Dep. Agr. 48 pp., illus. 1963.

[2]About 50 acres of native *Acacia koa* are planted on commercial forest land. The trees are branchy and poorly formed. Many have dead branches and rotten trunks. Planted koa stands were not measured in this inventory.

[3]Public or private lands administered by the State for management and protection of watersheds and other forest values.

[4]See definitions of terms in Appendix.

The plantings of Monterey, loblolly, and slash pines established in the late 1950's and early 1960's have formed sapling and pole-size stands. However, these trees were planted at a wide spacing strictly for watershed improvement purposes and probably will not develop good sawtimber stands.

Timber Volume

The planted forests on Lanai contain 2.9 million board feet of sawtimber (table 3). Nearly 2.2 million board feet of this volume consists of eucalypts; the volume in robusta eucalyptus alone amounts to 1.7 million board feet. Molucca albizzia is the only other species of relatively large volume--about one-half million board feet. The combined volume in tropical ash, turpentine-tree, Australian redcedar, and Norfolk-Island-pine amounts to about one-quarter million board feet. About 80 percent of the sawtimber volume is in trees less than 19 inches d.b.h. (table 4). Generally, the trees on Lanai are smaller than trees on the other islands. Only a few stands have trees more than 100 feet tall.

The total growing stock volume in planted sawtimber stands is only about 800,000 cubic feet. About 77 percent of this volume is in eucalyptus species--more than half is robusta eucalyptus.

Poletimber and sapling stands contain additional growing stock volume, but these were not measured.

Wood in cull trees in the planted sawtimber stands totals nearly 40,000 cubic feet. The 75 acres of noncommercial plantations also hold a volume of wood in cull trees, but these ironwood, paper-bark, and Monterey cypress stands were not measured.

Age of Stands

Forestation was started later on Lanai than on the other islands. Most plantings were done in the 1920's and early 1930's (table 2). Therefore, nearly all the sawtimber stands are less than 40 years old. A small reforestation effort was resumed in the 1950's.

Stand Yields

The average yield of sawtimber in planted sawtimber stands on Lanai is just under 9,000 board feet per acre (table 6). But yields differ widely by stand age, species, site, history and condition of stand, and other factors. The highest yield was measured in a 30-year-old plantation of blackbutt eucalyptus. This 5-acre stand had a net average volume of 20,256 board feet per acre. Robusta eucalyptus stands averaged almost 11,000 board feet per acre.

Yields are lower on Lanai than the averages for the Islands of Kauai and Hawaii. This condition is probably due to poorer sites and younger age of stands on Lanai. Some of the Australian redcedar trees growing in well-drained narrow valley bottoms are, however, impressive. Turpentine-tree shows good growth. Tropical ash and robusta growth are not impressive.

Australian toon shows excellent form and growth in protected and well drained pockets.

Robusta eucalyptus, generally a wet site species, does poorly on Lanai's drier sites.

Tropical ash and turpentine-tree (rough bark) grow well in valley bottoms on well-drained soil.

Timber Quality

Molucca albizzia has the highest quality logs, as determined by standard hardwood log grades (table 5).[5] The species has about 45 percent of its volume in grade 1 and 2 logs. Nearly 80 percent of the robusta eucalyptus volume is in grade 4 logs and only 5 percent in grade 1 and 2 logs. The quality of robusta eucalyptus timber on Lanai is inferior to that on the other islands.

Values of Forest Development

The small acreage of commercial forest land on Lanai has a relatively low productive capacity for timber. The potential for growing sawtimber is probably not much more than 500,000 board feet per year. This volume is not an adequate timber resource base to support a milling industry.

But the plantation forests are a source of wood products for local use: timbers, poles, posts, fuelwood, craftwood, and other products. Also, there are opportunities to produce even more for local use by managing forest plantations and reforesting additional lands.

Furthermore, timber and other wood products are not the only values to be gained from forest plantations. Their value for watershed cover and shelterbelts and for improved recreation and wildlife habitats will likely far exceed the value of any wood products harvested.

Forests on Lanai help control erosion caused by wind and water. Some of the forest plantings are considered to be extremely beneficial to watershed values on the slopes of Lanaihale. Shelterbelts are needed on the central plateau, but species selection and establishment are difficult on these rigorous sites.

The existing forest plantations demonstrate that attractive outdoor recreation habitat can be developed. Planted stands, free from obstructing underbrush, are ideal for hiking, picnicking, camping, and bridle trails.

The forest areas on Lanai provide excellent game habitats. To improve the game resource, the Hawaii Fish and Game Division administers an active game management program. Some of the planted forests provide the best game habitat on the island.

Forestation can improve watershed, scenic, recreation, and wildlife values on many additional acres on Lanai. These benefits, singly or combined, may make forestation on large acreages of land a highly desirable goal. On this small, dry island, such a potential should not be overlooked.

---

[5] Quality of wood as determined by physical properties and mechanical characteristics inherent in species is not a consideration in this classification.

Ironwood species provide excellent shelterbelts for pineapple fields on this dry area.

Much of Lanai's lower areas are covered with scattered kiawe and grass. The Island's principal game habitat is found there.

Almost 6 percent of Lanai's land area is characterized by steep slopes and pali lands.

Forestry and game management officials assess the recreation potentials of a planted forest.

Recent plantings of loblolly, slash, and Monterey pines have been made for watershed protection.

Appendix

Definitions

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground.

Commercial forest land: Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.

Noncommercial forest land: (a) *Productive-reserved* forest land withdrawn from timber use through statute or administrative regulation, and (b) *unproductive* forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of growing space is occupied by planted species (usually exotic), regardless of native species predominance.

Commercial forest plantation: A plantation of commercial tree species on commercial forest land.

Noncommercial forest plantation: A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuelwood or fence posts are excluded. The following species are in the planted stands:

Scientific Name	*Common Name*
Acacia koa	koa
Albizia falcata	Molucca albizzia
Araucaria excelsa	Norfolk-Island-pine
Eucalyptus botryoides	bangalay eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus sideroxylon	red-ironbark eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Pinus elliottii	slash pine
Pinus radiata	Monterey pine
Pinus taeda	loblolly pine
Syncarpia glomulifera	turpentine-tree
Toona ciliata var. *australis*	Australian redcedar (toon)

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following species are in the planted stands:

Scientific Name	*Common Name*
Casuarina spp.	ironwoods
Cupressus macrocarpa	Monterey cypress
Eucalyptus globulus	bluegum eucalyptus
Melaleuca leucadendron	paper-bark

Hardwoods: Dicotyledonous trees; usually broadleaved.

Softwoods: Coniferous trees, usually evergreen, having needle or scale-like leaves.

Forest types: Planted forests which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type or tropical ash type. Otherwise they are designated:

Commercial eucalyptus type: Planted stands predominantly of eucalyptus species, in which other hardwoods or conifers comprise less than 25 percent of the stand.

Commercial hardwood type: Planted stands predominantly of hardwoods other than the eucalypts in which conifers or eucalypts comprise less than 25 percent of the stand.

Commercial conifer type: Planted forests predominantly of conifers (e.g. Norfolk-Island-pine, sugi, pines, and redwood) in which eucalypts or other hardwoods comprise less than 25 percent of the stand.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

Sawtimber trees: Live trees of commercial species of at least 11.0 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.

Poletimber trees: Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.

Saplings and seedlings: Live trees of commercial species between 1.0 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Sawtimber: Wood in trees defined as sawtimber trees.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections, V equals 0.905 $(0.22D^2 - 0.71D)$.

Sawtimber volume: The net volume of the saw-log portion of sawtimber trees, in board feet, International 1/4-inch rule.

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable sawlog cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5.0 inches d.b.h. or larger, from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches.

Stand-Size Class

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing stock.

Nonstocked: Commercial forest lands less than 10 percent stocked with growing stock trees.

Miscellaneous

Diameter breast height (d.b.h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as saw-logs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[6] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, these are usually inherent in a species.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand by plantation stand. First, individual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured on the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared electronic computer program. Tree measurements were converted to meaningful volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreages of the stand. The computer output consisted of tabular data for each stand and a summary of stand data. Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands.

The accuracy goal for this inventory was ± 20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. Calculations show that the reliability of the estimate of total sawtimber in measured stands is ± 6 percent two chances out of three.

---

[6] U.S. Forest Products Laboratory. *Hardwood log grades for standard lumber --proposals and results.* U.S. Forest Serv. Forest Prod. Lab. Rep. 1737, 15 pp., illus. 1953.

Table 1.--Area of forest plantations by forest type and stand-size class, Island of Lanai, 1966

Forest type	Stand-size class: Seedling & sapling	Poletimber	Sawtimber	Noncommercial	Total
	Acres				
Commercial types					
Robusta eucalyptus	--	--	153	--	153
Blackbutt eucalyptus	--	--	12	--	12
Other eucalypts[1/]	--	--	97	--	97
Molucca albizzia	--	--	21	--	21
Tropical ash	--	--	19	--	19
Turpentine-tree	--	--	4	--	4
Australian redcedar	--	--	3	--	3
Mixed hardwoods[2/]	--	--	15	--	15
Norfolk-Island-pine	--	--	3	--	3
Pine	70	--	--	--	70
Total	70	--	327	--	397
Noncommercial types					
Ironwood	--	--	--	35	35
Monterey cypress	--	--	--	40	40
Total	--	--	--	75	75
Total all types	70	--	327	75	472

1/ Includes bangalay, saligna, red-ironbark, and unidentified eucalyptus.
2/ Includes combination of the listed species.

Table 2.--Area of forest plantations by forest type and period planted, Island of Lanai, 1966

Forest type	Period of planting				Total
	1926-1935	1936-1945	1946-1955	1956-1965	
	Acres				
Commercial types					
Robusta eucalyptus	107	46	--	--	153
Blackbutt eucalyptus	4	8	--	--	12
Other eucalypts[1/]	--	97	--	--	97
Molucca albizzia	14	7	--	--	21
Tropical ash	--	19	--	--	19
Turpentine-tree	--	4	--	--	4
Australian redcedar	--	3	--	--	3
Mixed hardwoods[2/]	--	15	--	--	15
Norfolk-Island-pine	3	--	--	--	3
Pine	--	--	--	70	70
Total	128	199	--	70	397
Noncommercial types					
Ironwood	4	31	--	--	35
Monterey cypress	--	37	3	--	40
Total	4	68	3	--	75
Total all types	132	267	3	70	472

1/ Includes bangalay, saligna, red-ironbark, and unidentified eucalyptus.

2/ Includes combination of the listed species.

Table 3.--Volume of growing stock, sawtimber, and cull trees by species, in planted sawtimber stands, Island of Lanai, 1966

Species	Growing stock	Sawtimber	Cull trees
	Thousand cubic feet	Thousand board feet	Cubic feet
Robusta eucalyptus	450	1,672	19,262
Blackbutt eucalyptus	105	243	970
Other eucalypts	71	235	3,827
Molucca albizzia 1/	99	525	--
Tropical ash	47	108	3,670
Turpentine-tree	13	38	234
Australian redcedar	17	57	1,426
Other hardwoods 2/	--	--	1,680
Norfolk-Island-pine	9	42	--
Noncommercial species 3/	--	--	6,378
Total	811	2,920	37,447

1/ No Molucca albizzia stands were large enough to be cruised, but log volumes of similar measured stands on Kauai were used here.
2/ Includes silk-oak and koa.
3/ Includes Casuarina spp. and bluegum eucalyptus.

Table 4.--Volume of sawtimber and growing stock in planted sawtimber stands by species and diameter class, Island of Lanai, 1966

Species group	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9
	Thousand board feet[1]							
Australian redcedar	57	--	17	10	24	6	--	--
Blackbutt eucalyptus	243	--	45	88	34	36	40	--
Bangalay eucalyptus	17	--	--	--	--	5	--	12
Eucalyptus spp.	138	--	33	34	38	24	9	--
Molucca albizzia[2]	525	--	11	63	63	104	280	4
Norfolk-Island-pine	42	--	--	--	15	27	--	--
Red-ironbark eucalyptus	80	--	16	30	13	13	8	--
Robusta eucalyptus	1,672	--	285	414	508	235	230	--
Tropical ash	108	--	45	31	24	8	--	--
Turpentine-tree	38	--	2	2	22	9	3	--
Total	2,920	--	454	672	741	467	570	16
	Thousand cubic feet							
Australian redcedar	17	5	5	2	4	1	--	--
Blackbutt eucalyptus	105	5	30	41	15	8	4	2
Bangalay eucalyptus	3	--	--	--	--	1	--	2
Eucalyptus spp.	42	3	12	12	8	5	2	--
Molucca albizzia[2]	99	7	7	14	14	18	38	1
Norfolk-Island-pine	9	--	--	--	4	5	--	--
Red-ironbark eucalyptus	26	7	5	7	3	2	2	--
Robusta eucalyptus	450	59	102	98	102	47	42	--
Saligna eucalyptus	(3/)	--	--	--	--	--	--	--
Tropical ash	47	14	15	10	7	1	--	--
Turpentine-tree	13	1	2	2	5	2	1	--
Total	811	101	178	186	162	90	89	5

1/ International 1/4-inch rule.
2/ Diameter classes applied to this species were derived from similar sawtimber-size stands of this species on Kauai.
3/ Less than a thousand cubic feet.

Table 5.--Sawtimber volume in planted sawtimber stands by species groups and log grade[1/] Island of Lanai, 1966

Species group	All grades	Factory lumber grades			Tie and timber logs: Grade 4	Softwood species [2/]
		Grade 1	Grade 2	Grade 3		
	Thousand board feet[3/]					
Robusta eucalyptus	1,672	11	66	273	1,322	--
Other eucalypts[4/]	516	13	15	54	434	--
Molucca albizzia[5/]	525	164	73	125	163	--
Tropical ash	108	--	3	25	80	--
Australian redcedar	57	--	--	12	45	--
Norfolk-Island-pine	42	--	--	--	--	42
Total	2,920	188	157	489	2,044	42

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ Commercial conifer species are not log graded.
3/ International 1/4-inch rule.
4/ Mainly *Eucalyptus* spp. but includes turpentine-tree.
5/ No Molucca albizzia stands were cruised on Lanai, but log grades of similar measured stands on Kauai were used here.

Table 6.--Listing of individual stands and plantings with species type, area, and volume, Island of Lanai, 1966

Stand no.[1]	Species type	Acres	Total stand volume
			Thousand board feet
5001	Ironwood	12	(2/)
5002	Robusta eucalyptus	4	66
5003	Mixed eucalyptus	41	363
5004	Robusta eucalyptus	10	36
5005	" "	10	16
5006	Turpentine-tree	4	4
5007	Mixed species	11	145
5008	Pine	3	(3/)
5009	Robusta eucalyptus	9	8
5010	" "	2	2
5011	Robusta eucalyptus	10	51
5012	Monterey cypress	3	(2/)
5013	Robusta eucalyptus	4	68
5014	Mixed eucalyptus	26	73
5015	Monterey cypress	2	(2/)
5016	Robusta eucalyptus	3	50
5017	Ironwood	2	(2/)
5018	Robusta eucalyptus	4	66
5019	Ironwood	4	(2/)
5020	Mixed eucalyptus	2	41
5021	Blackbutt eucalyptus	3	61
5022	Robusta eucalyptus	6	99
5023	" "	13	221
5024	" "	2	33
5025	" "	2	34
5026	Robusta eucalyptus	3	50
5027	" "	3	50
5028	" "	2	33
5029	" "	3	50
5030	Norfolk-Island-pine	3	8

1/ These numbers identify specific stands delineated on aerial photographs which were used to make this inventory.

2/ Noncommercial plantation type.

3/ Poletimber or seedling and sapling stands.

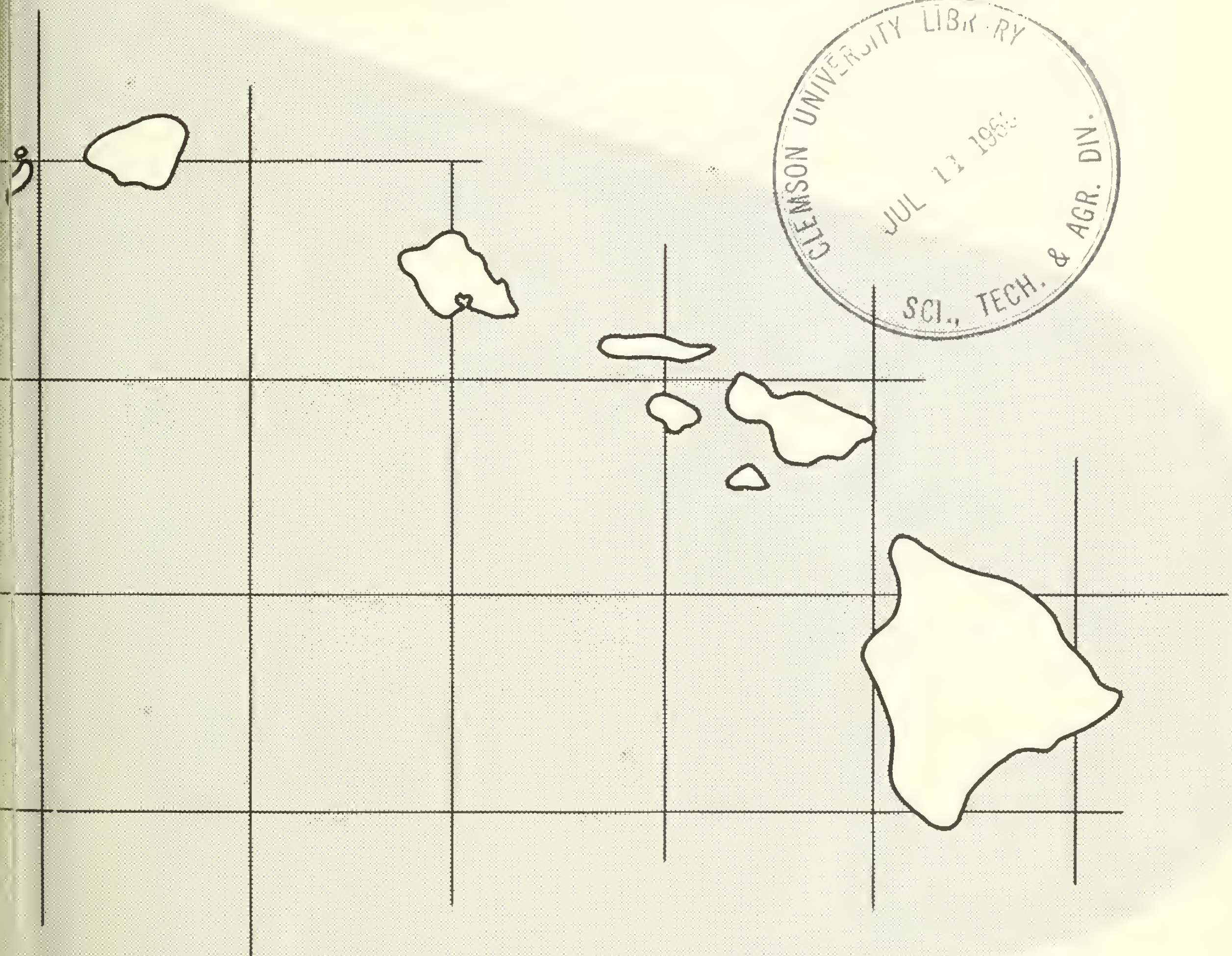
Table 6, continued

Stand no.	Species type	Acres	Total stand volume
			Thousand board feet
5031	Robusta eucalyptus	2	33
5032	" "	2	33
5033	Pine	29	(3/)
5034	"	38	(3/)
5035	Robusta eucalyptus	8	75
5036	Ironwood	4	(2/)
5037	Mixed eucalyptus	8	31
5038	" "	20	42
5039	Robusta eucalyptus	23	66
5040	" "	18	29
5041	Australian redcedar	3	39
5042	Tropical ash	2	3
5043	" "	6	10
5044	" "	5	28
5045	Blackbutt eucalyptus	5	101
5046	Monterey cypress	35	(2/)
5047	Molucca albizzia	4	89
5048	Mixed species	4	53
5049	Molucca albizzia	3	67
5050	Ironwood	9	(2/)
5051	Molucca albizzia	4	89
5052	Ironwood	4	(2/)
5053	Robusta eucalyptus	4	66
5054	Tropical ash	2	11
5055	Robusta eucalyptus	4	68
5056	Molucca albizzia	3	67
5057	" "	4	89
5058	Robusta eucalyptus	2	33
5059	Blackbutt eucalyptus	4	81
5060	Molucca albizzia	3	67
5061	Tropical ash	4	22
	Total Forest Plantation	472	2,920

GPO 975-409

U. S. FOREST SERVICE
RESOURCE BULLETIN
PSW - 8 1967

Records and Maps of Forest Types in Hawaii



Pacific Southwest Forest and Range
Experiment Station, Forest Service,
U. S. Department of Agriculture,
Berkeley, California 94701

and

Division of Forestry,
Department of Land
and Natural Resources,
State of Hawaii,
Honolulu, Hawaii 96813

Records and Maps of Forest Types in Hawaii

Robert E. Nelson

Contents

U.S. Forest Service research in Hawaii
is conducted in cooperation with
Division of Forestry
Hawaii Department of Land and Natural Resources

The Author

ROBERT E. NELSON heads the Station's Institute of Pacific Islands Forestry, headquartered in Honolulu, Hawaii. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office.

ACKNOWLEDGMENTS

I want to acknowledge, with much appreciation, the advice and comments provided me by E. H. Bryan, K. H, Korte, and R. K. LeBarron, who reviewed the manuscript.

How does forest vegetation in Hawaii differ today from that a thousand years ago? What is the present nature and extent of forests in the Islands? In 1958 the U.S. Forest Service began to survey the forest resources of Hawaii to collect information for land use planning and management. As part of this job we compiled maps of forest types to show vegetation cover. And, in the process of making the forest resource survey, we looked into past as well as present records. The information we have gathered on former vegetation and land use should be useful to geographers, ecologists, historians, and students.

The present pattern of dominant plant associations in Hawaii and their floristic composition has resulted from marked and rapid change. Beginning more than a thousand years ago with the first Polynesian settlers, the impact of agriculture has profoundly changed the vegetation composition and distribution. When Captain James Cook discovered the Islands in 1778, he saw in large part a man-made and managed landscape. Change was accelerated after discovery of the Islands and continues today at a rapid rate. Both forests and other plant communities have been greatly affected.

Early Records of Vegetation

The record of vegetation in the Islands in the late 1700's is not entirely clear, but we do have accounts by many early visitors who wrote about the landscape they saw. Some writers provided details about one location or another, including descriptions of vegetation types and plants encountered (Hosaka 1931; Korte 1961; MacCaughey 1918). From these descriptions we can visualize the major vegetation features of the landscape. Much of the lowlands, even in wet areas, must have lacked forest, and a large part was probably cultivated.

One of the early visitors, Menzies (1793), wrote about lands in Hamakua:

"The land we passed in the forenoon rose in a steep bank from the waterside and from thence the country stretched back with an easy acclivity for about four or five miles, and was laid out in little fields, apparently well cultivated and interspersed with habitations of the natives. Beyond this the country became steeply rugged and woody, forming mountains of great elevation."

After sailing from Hamakua and anchoring at Kawaihae, he wrote:

"From the north-west point of the Island, the country stretched back for a considerable distance with a very gradual ascent, and is destitute of trees or bushes of any kind. But it bears every appearance of industrious cultivation by the number of small fields into which it is laid out...."

Menzies wondered how the dry rocky lowlands could support such a large number of people. His statements suggest that the Waimea area of the Island of Hawaii was heavily populated and cultivated as was the area above Kealakekua Bay inland from the lower "dry barren rocky country":

"For several miles around us there was not a spot that would admit of it but what was with great labor and industry cleared of the loose stones and planted with esculent roots or some useful vegetable or other.... But seeing now these upper regions so industriously cultivated and teeming with productive crops, we could no longer remain ignorant of their vast resources...."

Fifteen years earlier, in 1778, David Nelson, the first botanist to visit the Hawaiian archipelago, had landed with Captain Cook on the Kona coast. He and John Ledyard attempted to climb Mauna Loa from Kealakekua. They noted that the forests did not reach the shore. Wrote Ledyard:

"It was now near sunset, and being upon the skirts of these woods, that so remarkedly surrounded this island at a uniform distance of four or five miles from the shore, we concluded to halt,...."(MacCaughey 1918a, pp. 388-396).

The "native" landscape that Captain Cook and other early visitors saw in the lowlands was largely a result of activities for a thousand years of the heavy Hawaiian population. It is common knowledge that the Hawaiians had introduced a considerable variety of Polynesian economic plants during their migrations from the South Pacific (Neal 1948). Ledyard's description during his 1779 hike above Kealakekua is typical. "On first leaving the town, their route lay through enclosed plantations of sweet potatoes. Now and then a patch of sugar cane was seen. Next came the open plantations, consisting chiefly of breadfruit trees, and the land began to ascend more rapidly."(MacCaughey 1918a).

Menzies (1793) wrote that the Kau area "bore in general a very barren and rugged appearance." Later, describing his ascent of Mauna Loa, he wrote of many plantations between South Point and Kapapala and described the upper forest edge as at 6,500 feet elevation.

Captain George Vancouver remarked about extensive taro, sugar cane, sweet potato and breadfruit cultivation on Kauai, Oahu, Maui, and Hawaii during his visits from 1792 to 1794 (MacCaughey 1918b). In 1816 the Russian Captain Otto von Kotzebue remained in the Honolulu area for 2 weeks and described a walk from Honolulu to Pearl Harbor (MacCaughey 1918b, p. 425):

> "The road...lay toward the west, through a beautifully cultivated valley (Nuuanu), bordered in the north by a romantic wilderness.... Sugar plantations, taro fields, and far-scattered plantations succeeded each other on our road, and we had inadvertently travelled five miles to the great village Mauna Roa (Moanalua)...."

Kosaka (1931, p. 16) quoted Macus (Macrae),[1] who visited the Islands in 1825 and described lands above Laupahoehoe on the Island of Hawaii as follows:

> "The land six miles inland shows no sign of cultivation. It is not even pastured by livestock, being covered with long grass and short stumpy tree ferns belonging to the Cyathea tribe. We reached the outskirts of the woods between three and four in the afternoon, having on our way crossed three narrow, deep ravines, thickly covered with wood, mostly metrosideros, aleurites and a species of Rhus."

Describing the Hilo-Hamakua area, Macrae (1825, p. 57) wrote:

> "The land along the sea coast from Byron's Bay [Hilo] to upwards of 40 miles to the west and about 6 miles in breadth, was free from wood excepting by the sides and bottoms of ravines. The forest that surrounds the central part of the island begins here, at a distance of 5 or 6 miles from the coast, and stretches back for a depth of 12 miles, intersected with deep valleys and large rivers of fine water.... The upper parts of the forest resemble pasture land for 7 miles further and are thinly covered with low growing shrubs and abundance of strawberries and raspberries."

Menzies (1793) noted the purposeful and frequent burning by the natives of the grassy plains in Waimea, Kauai, so that "grass grew up clear and free of stumps and was therefore better

[1] I believe that Hosaka's Macus is Macrae.

adapted for thatching...." He also wrote of the cutting of huge koa trees for canoe logs and introduction of plants by natives along forest trails.

Although we are left to wonder about the nature of vegetation at specific locations, such accounts of the early explorers challenge the creditility of some later theorizing. Judd (1918, pp. 117-133) stated that "on Oahu the Leilehua plateau between the Waianae and Koolau ranges was no doubt once densely forested." But Hosaka (1931, pp. 7-8) wrote of the same area:

> "It is believed that the great plateau of Wahiawa was once thickly forested but I could not find any first hand authentic statement."

And he cites Hunnewell to show that "at least by 1825 this central plain was devoid of trees."

Koebele (1900, pp. 90-97) speculated that "If we could look backward fifty or sixty years we would see the two large mountains of Maui meet by trees in the plains; Lanai and Molokai clothed with forests, ..." But Hosaka (1931, pp17-19) cites early observers to the contrary.

Hall (1904, pp. 84-102) discussed the natural conditions of rainfall, elevation, and lava flows that limited the forested area. He claimed that these "were the chief agencies restricting the forest up to about 100 years ago." Hall did not comment on the impact of use of fire, cultivation, and fuelwood cutting by early Hawaiians.

Crosby (1955, pp. 28-34) also discounted the effect of activities of the Hawaiians on the vegetation:

> "Various remnants of native forest indicate that the first Polynesian settlers found trees growing on all parts of the Hawaiian Islands except a few very dry leeward areas and recent lava flows. The Polynesians cleared only limited areas for cultivation and made little use of forest products, so forest must have occupied most of the land when the islands were discovered by Captain Cook in 1778."

Yet there were probably more than 300,000 Hawaiians in the Islands in the late 1700's (Territorial Planning Board 1939, p. 23). The effect of this large agrarian force on the Hawaiian landscape was obvious to the early visitors, but not to those who came later. Neither the early visitors nor later writers have commented on the effect of pigs, rats, dogs and chickens introduced to the Islands by the Polynesian settlers, yet these animals must have had a heavy ecological impact on the native plant communities.

Vegetation Changes After 1778

Neither the Hawaiians nor the early geographers and botanists have left a clear record of the extent of native forests in the Hawaiian Islands as they found them. They provided a much better record of the indigenous floristic composition than of its distribution and ecology (Bryan 1929). The first resident botanist in the islands, Hillebrand (1888), spent 20 years studying and classifying the flora. He describes "zones of elevation" occupied by different groups of flora. However, by 1851 when he began his studies, livestock grazing, and sandalwood cutting had already caused marked changes in the composition and extent of the forests. Other agents were also having an increasing impact on the vegetation in the Islands.

We can conclude from early descriptions that before extensive sandalwood cutting and introduction of livestock, dense forests covered much of the land above the cultivated areas and up to about 6,000 feet, especially on windward slopes. Today, they still do but apparently to a much less extent. At higher elevations, however, the forest thinned out, as described by Menzies (1793) and Macrae (1825). Many forces have worked since to decrease the forests and otherwise modify the vegetation in the Islands.

There are still extensive areas of virgin ohia-treefern rainforest in Hawaii, but certainly much less than when Captain Cook discovered the Islands in 1778.

Timber Harvesting

Sandalwood harvesting started in 1791 and increased tremendously during the next 40 years (Thrum 1904). Hundreds of Hawaiians were engaged in cutting and hauling the wood from the mountains. This activity had lasting effect on the forest. Too late, Hawaii's first conservation law was passed in 1839, restricting cutting of sandalwood (Thrum 1904). Three-quarters of a century later, Rock (1913, p. 127) reported: "Since the large export of Sandalwood from these Islands to China, the trees have become rather scarce and only individual ones can be found scattered through the drier forests." Sandalwood trees are still scarce, but not rare.

Cutting of forest products has considerably modified the forests. The Hawaiian Planters' Monthly (1887, p. 437) reported:

> "From every part of the islands comes the same complaint relative to the destruction of the forests. ...the charge, perhaps, ought to be laid at the door of the landowners, who allow so much wood [fuel] to be cut on their estates."

Giffard (1913, p. 42) showed concern over the cutting of fuelwood:

> "The old time practice of denuding native forest areas in proximity to sugar mills, in order to secure fuel for factories, has practically ceased, but there are many sections on some of the islands where the native forests are still used as a source of fuel supplies, regardless of the disturbance and subsequent harm it does."

Korte (1961, p. 3) concluded that the demand for fuelwood by the whaling ships between 1824 and 1861 was such that "at least 10,000 acres of native forests were cut." He also cites the culture of a native fungus for food as the cause of cutting large areas of kukui forests. This was a commercial enterprise. The fungus grew well on logs felled for this purpose. Lydgate (1882, pp. 33-35) indicated that the lumber industry had an impact on the forests at an early date:

> "In early times koa sawing was a regular and flourishing business.... The upland region of Hamakua, Hawaii was the center of the lumbering...and from there the lumber was mostly hauled to Waimea and thence to Kawaihae, giving to those places a degree of life and activity which they seem never likely to see again."

Korte (1961, p. 54) cites records of sawmills cutting koa prior to 1854 in East Makawao and Kula on the island of Maui. Timber cutting has continued intermittently on a small scale to the present, the greater part being in connection with land clearing for pasture use.

Harvest of tree fern products has had an impact on the rain forest for an extended period. The plants provide useful food and fiber products (Hubbard 1952; Korte 1961; Nelson and Hornibrook 1962; Ripperton 1924; Wold, n.d.).

Animals and Insects

Livestock are generally held responsible for the pronounced depletion of forests in all regions (Hall 1904; Judd 1918; Maxwell 1899). Vancouver introduced goats, cattle, and sheep into the Islands in 1792, 1793, and 1794 (MacCaughey 1918b). Cleveland landed horses in 1803 (Editor, The Hawaiian Planters' Monthly 1888). With a taboo laid on these animals, their numbers increased rapidly and they spread wild into the mountains. That these feral animals had a profound effect on the vegetation can not be doubted, but the magnitude can never be known.

In recounting the impact of cattle on native agriculture during those earlier days, Alexander (1894, pp. 91-100) wrote:

> "In some districts agriculture was entirely ruined by the encroachments of herds of cattle, chiefly owned by foreigners.... These herds were allowed to increase without limit, until large tracts of country were completely overstocked, thousands of acres of fertile land laid waste, and the rights of native tenants literally trampled under foot. In 1851, fairly good cattle on Kauai were sold at two dollars a head, [for hides and tallow]...."

Marsden (1893, pp. 297-303) reported that ranching around Waimea, Island of Hawaii, increased greatly from 1873 to 1893 and cattle grazing caused destruction of forest on "probably 100,000 acres." John P. Parker, the founder of the famed Parker Ranch in Waimea, had begun cattle ranching activities by 1835 in this district (Honolulu Item, February 1930).[2]

Quoting from the memoirs of Wilder, Korte (1961, p. 54) gave an example of the effect of cattle ranching on the forests above Ulupalakua, Maui: "When Captain Makee in about 1852 started to grow cane at Ulupalakua a dense forest covered the side of Haleakala above the plantation ensuring sufficient moisture for crops. As years passed, cattle and other causes led to the destruction of the forest...."

Birds that were introduced to the Islands have a continuing effect on the vegetation. For example, the mynah is credited, along with other birds, as the chief agent for the spread of lantana (Perkins, 1903). Swezy (1954) cited a 1926 letter from Perkins who speculated that "When the mynah bird reached the height of their abundance in the forests, I believe the defoliation [of koa trees] by ... caterpillars really became much less frequent."

---

[2]Information on file in the Hawaii State Archives, Honolulu.

Insects and diseases have no doubt played a continuing role in determining the composition and extent of forests and the vegetative cycle. The impact of these agents has been severe at times (Lyon 1909). Korte (1961, p. 2) quoted the 1875 writings of Clark, who discussed dying koa trees and stands: "... it cannot be cattle, for in many places where these dead trees stand no four-footed creature ever set its hoof."

Fire

According to Hall (1904), fire "has done far more injury in Hawaiian forests than would be supposed in regions of so great rainfall." He told of extensive fires in the southern part of Hamakua and on Kauai and Maui. Judd (1918, pp. 117-133) emphasized that fires had a destructive effect on the forests in the past. Korte (1961) stated: "Old timers on Maui speak of a great fire that occurred in Kula in the 1880's which burnt for weeks." Walker (1888, p. 521) reported that "Messrs. Gay and Robinson consider that in Kauai the forests where protected from cattle, are not on the decrease, except where destroyed by bush fires." Fire continues to be a threat, and each year burns a considerable area of forest--even in wet areas. Recent examples include the 1,200 acres burned in April 1958 in the very wet Lihue-Koloa Forest Reserve on Kauai (Board of Commissioners of Agr. & Forestry 1958); and the 2,500-acre fire above Hanalei, Kauai, in June 1967.

Lava flows have cut spectacular swaths through the forests on the slopes of Mauna Loa and Hualalai, and volcanic ash and fumes have altered the vegetation over extensive areas.

Plant Introductions

Introduced plants have radically altered the landscape in many parts of the Islands. They have a continuing impact on the native vegetation and floristic composition. Among the many examples is Kiawe (*Prosopis pallida*), which was introduced in 1827 (Judd 1916, pp. 330-335). The plant has spread over much of the lowlands, occupying about 150,000 acres by 1961 (Nelson and Wheeler 1963). Another example is Lantana (*Lantana camara*), about which Walker (1888, p. 521) wrote: "The invasion of the lantana bush has become a matter for very serious consideration; in Kona, Hawaii, on some parts of Maui, on this Island [Oahu] and on Kauai...." Haole koa (*Leucaena glauca*), firetree (*Myrica faya*), Christmas-berry (*Schinus terebinthifolius*), guava (*Psidium* spp.), prickly pear cactus (*Opuntia megacantha*) and other pest species have naturalized over large acreages. Some valuable timber trees have naturalized in the dry areas, including monkey-pod (*Pithecellobium saman*) and silk-oak (*Grevillea robusta*) (Nelson 1960). Others, such as Java podocarpus (*Podocarpus cupressina*) can naturalize in the rain forest (Richmond 1965).

The potential for introduced plants to effect changes in the floristic composition in the Islands is suggested by the num-

Kiawe (Prosopis pallida) was introduced in 1827 and now occupies about 150,000 acres of dry lowlands in the Islands. Such areas were likely treeless when Captain Cook first saw Hawaii.

ber of introductions that have been made. The Hawaii Division of Forestry alone has recorded the planting of some 1,100 different species of trees and other plants in the forests on the different islands since 1908 (Nelson 1965). Bryan (1947) made an excellent appraisal of the adaptability of many species to sites on the Island of Hawaii. Some of the tree plantings established over the years are of considerable acreage and have developed into noticeable forest stands (Nelson and Honda 1966; Honda, et al. 1967). Lyon (1918, pp. 276-280) gave this reasoning for some of the introductions: "Recognizing that our present forests are doomed and that they do not afford suitable plants with which to build up new forests there is only one line of procedure left open to us--we must introduce and establish a new flora on our watersheds."

Earlier, Hosmer (Board of Agr. & Forestry 1910) had indicated much broader purposes for introduction of tree species:

> "...from the commercial standpoint much better results can be gotten from introduced species than from Hawaiian trees. The local needs in wood are for posts, ties,

Ohia-koa forests have been opened up, and grass replaces the fern understory on thousands of acres of ranch lands.

timber and fuel. These are best supplied by introduced trees, but by no means has the last word been raised as to what introduced trees are best for local conditions."

Less conspicuous but just as aggressive as woody plants are some of the grasses and herbs that have been introduced and spread by and for livestock (Rock 1913, p. 25). Land clearing for pasture development has been the major factor changing the vegetative landscape in Hawaii over the past 100 years or more. Each year still additional areas are cleared and planted with introduced grasses.

Sugar and pineapple plantations have been developed partly on land originally cultivated by the Hawaiians. Additional large acreages of plantations occupy lands described by early visitors as grass-covered or treeless. Large acreages of the plantations have also been developed on once forested land, but we can only conjecture as to the actual extent. Development of other crops has expanded in recent years but the areal extent has not been great.

The combined effect of these and other agents acting on the forest and other vegetation in the Islands has been to alter greatly the boundaries and composition of plant communities over the years. But major efforts have also been made to protect the forests. Notable are the works of foresters Hosmer and Judd. Hosmer, the first Territorial Forester, started the Forest Reserve system in the Islands in 1904. Judd, who succeeded Hosmer in 1914, continued the efforts to extend the Forest Reserve system. By 1931 more than 1 million acres were in Reserve status, and there was a concerted effort to rid these areas of all livestock and to prevent and control fires (Judd 1931, pp. 363-367). In 1966 nearly 1.2 million acres were in the Reserves (Dep. of Land & Natural Resources 1966, p. 48).

We now see a value in preserving natural areas that was not apparent earlier to those who decried the destruction of the forest because of watershed values. Some areas still can and should be selected and protected as natural areas. Foresters, botanists, and others are now working on this goal.

Forest Types and Forest Area

Judd (1918, p. 125) stated that in 1918 "...the present area of original forest lands in Hawaii, through various agencies has been reduced until now it covers approximately only 800,000 acres...." This figure coincides with the acreage of land in "forest reserve" status at that time and is obviously not a valid estimate of area of land having a forest cover.

The Territorial Planning Board (1939) published maps and tabular data on the area of forest land on the different islands for 1900 (1,289,100 acres), 1920 (816,900 acres), and 1937 (1,027,000 acres). Obviously the latter two figures are "forest reserve" areas rather than forested areas as other records show (Board of Commissioners of Agriculture and Forestry 1920, 1936). The 1900 figure, however, was apparently an estimate of the total area of main blocks of native rain forests at that time. Forest reserves and "approximate area of forest land not in reserve" were shown on the source maps (Carter 1906). Although some of the mamani (*Sophora chrysophylla*) type was included as forest on these maps, very little of the native dryland forest was included and none of the kiawe forest type. Thus the maps and forest acreage figures fell far short of representing the true area of forested land. Crosby (1955, p. 28) conjectured that "At the time of Captain Cook's visit, about 3 million acres... in the Hawaiian Islands must have been forested. Today remnants of the native forest measure less than one million acres...."

Before 1960 there had been no maps compiled to show in any detail the different forest and other vegetation types in the Islands. As indicated earlier, Hillebrand (1888) described "zones of elevation" occupied by different groups of flora. He did not, however, develop vegetation-type maps.

Rock (1913) gave an excellent review of the flora in his six "botanical regions." He discussed the vegetation found at fairly specific locations and provided a general picture of the areal extent of different vegetation types and flora described. In fact it is possible to relocate some of the areas he described (Mueller-Dumbois and Lamoureaux 1967). Rock did not publish maps showing distribution of vegetation.

Hosaka and Ripperton (1955, pp. 96-109) described and portrayed on maps five "vegetative zones" based on rainfall, elevation, and vegetation. They described the typical vegetation in these zones, but did not show the actual vegetation pattern in any detail. Other authors--including Hall (1904), Griffith (1903), Judd (1918), and Crosby (1955)--have described forest and other vegetation types in the Islands and their general distribution. Nelson and Wheeler (1963) provided the first and only relatively detailed information on the acreage of different defined vegetation and forest types in the Hawaiian Islands. Of their reported 2 million acres of forest land, nearly 1.1 million acres are native ohia (*Metrosideros collina*) or koa (*Acacia koa*) forest types. Their data are based on study of sample points on aerial photographs according to statistical sampling techniques. And their much-generalized portrayal of major forest types on very small scale maps was developed from study of aerial photos.

Aerial photographs have enabled the U.S. Geological Survey to provide some information about vegetation types on the standard topographic quadrangle maps the agency compiles of the Islands. In 1952, it produced the first quadrangle maps having color tints and symbols to show some of the broad vegetation types in Hawaii. These maps, which are nearly completed for all the Islands, provide a visual record of the broad vegetation pattern on the Islands.

Hawaii Forest Type Maps

The maps described in this report are the first published record giving emphasis to the kind and extent of forest types in the Hawaiian Islands. National Park areas are excluded from coverage. The first map (quadrangle) was published in 1963, the final ones in 1965.

These forest type maps (see map appended to this report) have been compiled through interpretation of aerial photographs. The date of photography varies from 1950 through 1954. Only limited ground reconnaissance was possible. Consequently, changes in features since photography are not all shown, and interpretive error in some details must be expected. Every effort has been made to fit type boundaries to the topography of available base maps. The maps are published as blue-line prints at a scale of 1:62,500 and are suitable for coloring for pictorial representation of the types delineated and classified. They are available for purchase from the U.S. Forest Service, 630 Sansome St., San Francisco, California 94111 or from the Division of Forestry, Hawaii Department of Land and Natural Resources, P.O.Box 621, Honolulu, Hawaii 96809.

These maps were compiled primarily to provide information on the kind and extent of the forest land and timber resources in the Hawaiian Islands. On the maps, different land and vegetation types are delineated by dashed-line boundaries. In general, map scale allowed delineation to a minimum of about 40 acres. Numerical symbols within each delineated area show the broad land-use class or vegetation type and, for forest land areas, the forest type. Density of tree cover, and tree stand size class are given for commercial forest lands. The legend prepared to accompany these forest type maps shows that land areas were delineated to show the following defined classes of land and vegetation:

Land Use Class	Map Symbol
Commercial forest land	11
Productive-reserved forest land	21
Noncommercial forest land	22
Noncommercial forest pali land	23
Urban-industrial areas	30
Cultivated land	31
Grassland, forest site	32
Grassland, nonforest site	33
Nonforest pali	34
Rockland, nonpali	35
Marsh land	36
Water	37
Other, not classified	99

All lands classed as forest lands are further classified as to defined forest cover types as follows:

Native or Naturalized Commercial Tree Types	Map Symbol
Ohia	11
Koa	12
Ohia-koa	13
Silk-oak	14
Monkey-pod	16
Other	15

Planted Commercial Tree Types	Map Symbol
Eucalyptus species	21
Cedrela-Albizia	22
Other hardwood species	23
Conifers	24

Noncommercial Tree and Shrub Types	Map symbol
Kukui	81
Ohia-koa	82
Kiawe	83
Other tree types	84
Haole koa, guava, lantana and other lowland brush types	85
Mamani and other upland brush types	86
Herbaceous types	87
Other types	88

For areas classed as commercial and productive-reserved forest lands, the maps show by additional numerical symbols, the density class (percent crown cover) of tree stands and size class of the forest stand as follows:

Density of Tree Cover	Map Symbol	Stand-size Class	Map Symbol
Dense	1	Light sawtimber	1
Semidense	2	Heavy sawtimber	2
Open	3	Poletimber	3
Nonstocked	6	Seedlings and saplings	4
		Nonstocked	6

Thus within each delineated area on the map are numerical symbols of two, four, or six digits. For example, the two-digit symbol 33 in a delineated area indicates the area is classed as grassland not having soils and climate suitable for growing timber. An area having the symbol 31 is cultivated land or improved pasture.

The four-digit symbol 22-83 in a delineated area indicates that the area is classed as noncommercial forest land (symbol 22) and the forest type is kiawe (83).

A six-digit symbol like 11-11-23 indicates that the area delineated on the map is classed as commercial forest land (11) having a stand of ohia trees (11), the tree canopy covering 40 to 69 percent of the ground (semidense, symbol 2) and the stand is of poletimber size trees (symbol 3).

A sample map at a much reduced scale is appended to this report as *Map A*. Also, quadruplet copies of a sample section of the map--at slightly reduced scales--are appended. They are included to indicate what use can be made of the Hawaii Forest Type Maps.

On *Map B*, delineated areas of a portion of the map have been shaded or stipled in different patterns to show different land classes. This shading is based on the first or only pair of symbols in each area.

On *Map C*, the same delineated areas were examined and shaded to show the different forest types. This shading is based on the second pair of symbols in the delineated areas. The nonforest areas are not shaded.

On *Map D*, the shading differentiates the density of tree stands only in the ohia forest types on *commercial forest land*. This shading is based on the first digit in the last pair of symbols.

Map E shows the same areas shaded to show the different size classes of ohia tree stands.

The best way of using these maps is through use of color shadings to highlight features of interest to the user. A variety of combinations is possible. The selection depends upon the purpose. Whatever color shading system is used, the basic classification symbols on the map can be referred to for details about a given delineated area.

The maps portray land use and vegetation cover types at a point in time. With time, land uses and vegetation change. In some areas change will be slow. In others change will be rapid and drastic, as where forest is cleared for subdivisions or pasture development. Slow or fast, minor or major, continued change is inevitable.

Map A

HAWAII FOREST TYPE-MAP

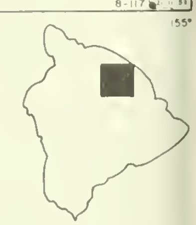
Cooperating agencies
PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE — U.S. DEPT. OF AGRICULTURE
DEPARTMENT OF LAND & NATURAL RESOURCES —
STATE OF HAWAII — FORESTRY DIVISION

(LAND USE — FOREST TYPE — DENSITY & SIZE CLASS —)
(see legend separate)

Map compilation by J. Klingensmith, 1962
Aerial photo interpretation by N. Honda, 1961
Year of aerial photography 1954
(Scale 1:33000 — 1:39000)

Road
Trail
Admin. Boundary
Named Location
Streams
Building
Photo Center

Base map and land grid U.S.D.I.G.S. Mauna Kea Quadrangle, 15' series Edition of 1943

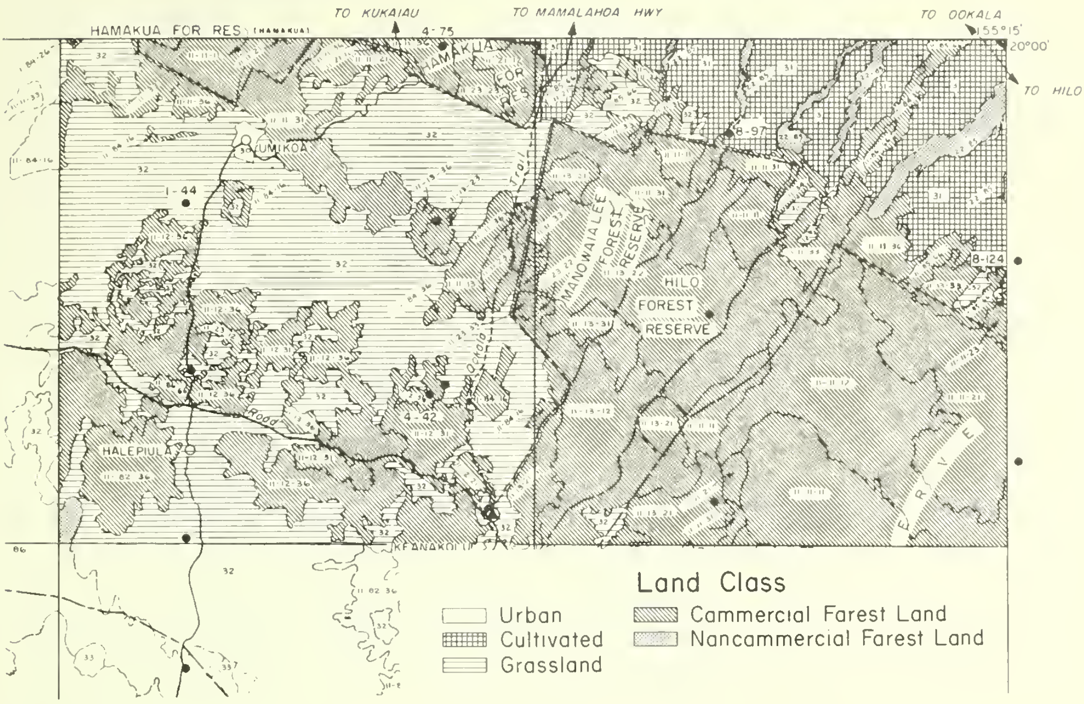


MAUNA KEA QUADRANGLE

Map B

HAWAII FOREST TYPE-MAP

(LAND USE — FOREST TYPE — DENSITY & SIZE CLASS —)
(see legend separate)

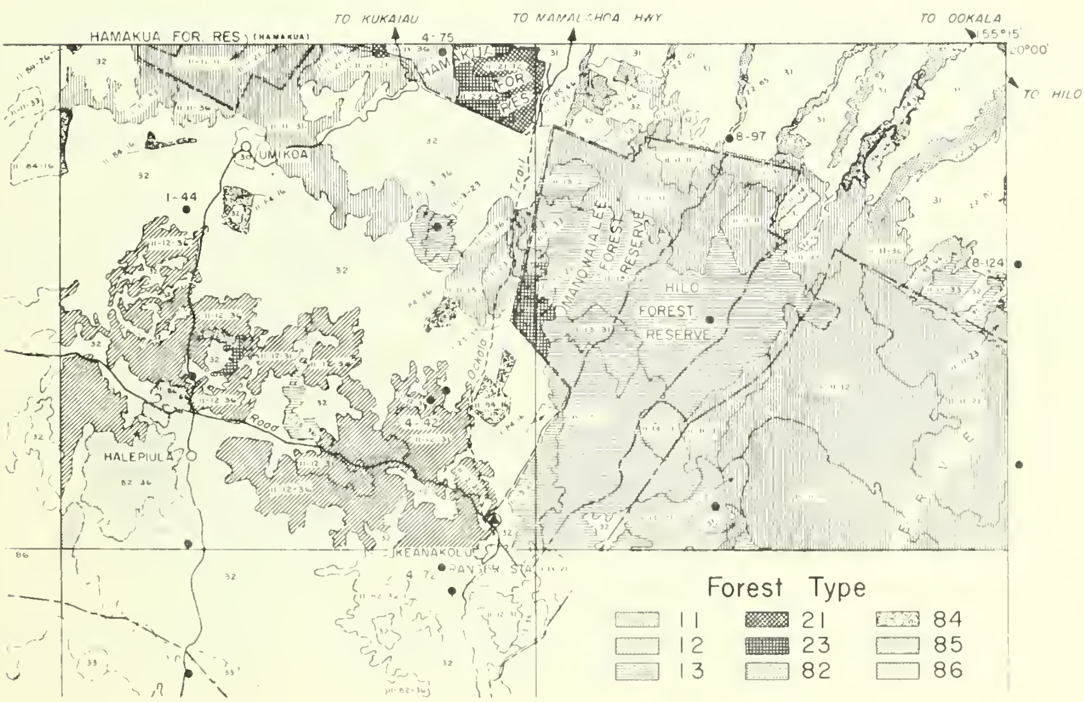


MAUNA KEA QUADRANGLE

Map C

HAWAII FOREST TYPE-MAP

(LAND USE — FOREST TYPE — DENSITY & SIZE CLASS —)
(see legend separate)

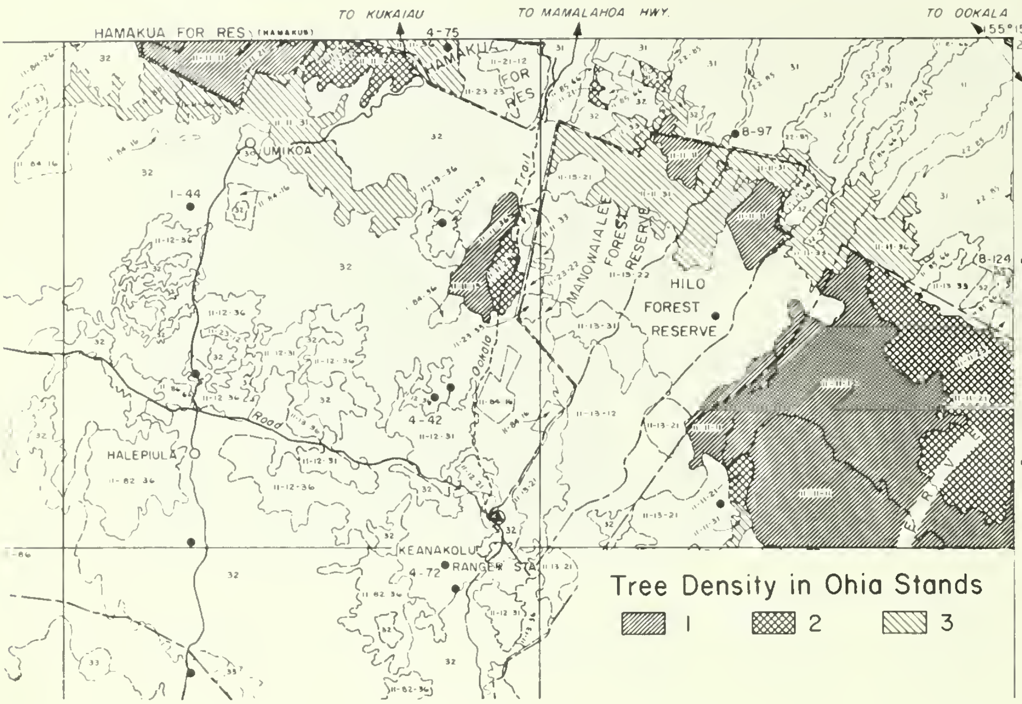


Map D

MAUNA KEA QUADRANGLE

HAWAII FOREST TYPE-MAP

(LAND USE—FOREST TYPE—DENSITY & SIZE CLASS —)
(see legend separate)

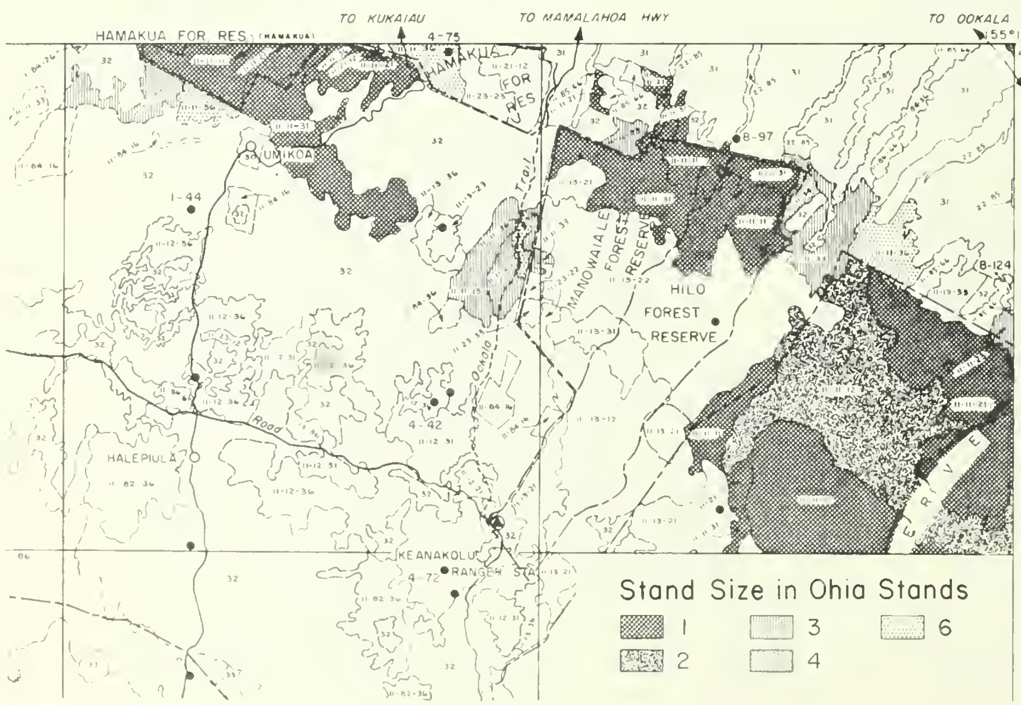


Map E

MAUNA KEA QUADRANGLE

HAWAII FOREST TYPE-MAP

(LAND USE—FOREST TYPE—DENSITY & SIZE CLASS —)
(see legend separate)



Literature Cited

Alexander, W. D.
1894. *Early industrial teachings of Hawaiians.* Thrum's Hawaii. Almanac and Annual for 1885:91-100.

Bryan, E. H., Jr.
1929. *The background of Hawaiian botany.* The Mid-Pacific 37:33-40, illus.

Bryan, L. W.
1947. *Twenty-five years of forestry work on the Island of Hawaii.* The Hawaii. Planters' Record 51(1):1-80, illus.

Board of Commissioners of Agriculture and Forestry.
1910. *Plant introduction work.* Rep. Supt. of Forestry for the Bein. Period ending Dec. 31, 1910, pp. 17-55.

Board of Commissioners of Agriculture and Forestry.
1920. *Lands in forest reserves.* Rep. Supt. of Forestry for the Bien. Period ending Dec. 31, 1920, pp. 50-60.

Board of Commissioners of Agriculture and Forestry.
1936. *Rep. Ter. Foresters for the Bien. Period ending Dec. 31, 1936.* pp. 17-33.

Board of Commissioners of Agriculture and Forestry.
1958. *Rep. for Bien. Period ending June 30, 1958.* Div. of Forestry and Ter. Parks, pp. 118-157, illus.

Carter, G. R.
1906. *Report of the Governor of the Territory of Hawaii to the Secretary of Interior.* Wash. Gov. Printing Office. 122 pp., 9 maps.

Crosby, William.
1955. *Vegetation.* Soil Survey, Ter. of Hawaii, Ser. 1939, No. 25, Sept. 1955. U.S. Dep. Agr. Soil Conserv. Serv., pp. 28-34, illus.

Department of Land and Natural Resources, State of Hawaii.
1966. *Report to the Governor for the fiscal period 1964-1966.* 76 pp., illus.

Editor, The Hawaiian Planters' Monthly.
1887. The Hawaii. Planters' Monthly 6(10):437.

Editor, The Hawaiian Planters' Monthly.
1888. *Incidents in the history of the Sandwich Islands a century ago.* The Hawaii. Planters' Monthly 7(3): 108-114.

Giffard, W. M.
1913. *Some observations on Hawaiian forests and forest cover in their relation to water supply.* Rep. Board of Commissioner of Agr. and Forestry for the Bien. Period ending Dec. 31, 1912. Honlulu, T.H. pp. 27-43, illus.

Griffith, E. M.
1903. *Report of expert forester on Hawaiian forests.* The Hawaii. Planters' Monthly 22(3):128-139.

Hall, William L.
1904. *The forests of the Hawaiian Islands*. Bur. Forestry, U.S. Dep. Agr. Bull. 48, 29 pp., illus.

Hillebrand, William M. D.
1888. *Flora of the Hawaiian Islands*. 673 pp., 4 maps. New York and London: Hafner Publishing Co.

Honda, Nobuo, Wong, Wesley H. C., Jr., and Nelson, Robert E.
1967. *Plantation timber on the Island of Kauai--1965*. U.S. Forest Serv. Res. Bull. PSW-6. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 34 pp., illus.

Hosaka, Edward Y.
1931. *History of the Hawaiian forest*. Univ. of Hawaii, Survey 251, 1931. 25 pp.

Hosaka, Edward Y., and Ripperton, J. C.
1955. *Soils and vegetation*. Soil Survey, Ter. of Hawaii, Ser. 1937. (25):96-109.

Hubbard, Douglass H.
1952. *Ferns of Hawaii National Park*. Hawaii Nature Notes 5(1):1-40, illus.

Judd, C. S.
1916. *The first algaroba and royal palm in Hawaii*. The Hawaii. Forester and Agr. 13(9):330-335.

Judd, C. S.
1918. *Forestry as applied in Hawaii*. The Hawaii. Forester and Agr. 15(5):117-133.

Judd, C. S.
1931. *Forestry in Hawaii for water conservation*. J. Forestry 29(3):363-367.

Koebele, A.
1900. *Hawaii's forest foes*. Thrum's Hawaii. Almanac and Annual for 1901:90-97.

Korte, Karl H.
1961. *A brief history of the forest reserves on the Island of Maui, State of Hawaii*. Div. Forestry, Dep. Land and Natur. Resources, 79 pp.

Lydgate, J. M.
1882. *Hawaiian woods and forest trees*. Thrum's Hawaii. Almanac and Annual for 1883:33-35.

Lyon, Harold L.
1909. *The forest disease on Maui*. The Hawaii. Planters' Rec. 1:92-95; 151-159.

Lyon, Harold L.
1918. *The forests of Hawaii*. The Hawaii. Planters' Rec. 18:276-280.

MacCaughey, Vaughan.
1918a. *History of botanical exploration in Hawaii--Period I*. The Hawaii. Forester and Agr. 15(9):388-396.

MacCaughey, Vaughan.
1918b. *History of botanical exploration in Hawaii--Period II*. The Hawaii. Forester and Agr. 15(10):417-429.

Macrae, James.
1825. *With Lord Byron at the Sandwich Islands in 1825.* Being extracts from the M.S. Diary of James Macrae, Scottish Botanist. Foreword by Wm. F. Wilson, Honolulu, 1922. 75 pp., illus.

Marsden, J.
1893. An article in The Hawaii. Planters' Monthly. 22:297-303.

Maxwell, Walter.
1899. *The Hawaiian Islands.* Thrum's Hawaii. Almanac and Annual for 1900:61-85.

Menzies, Archibald.
1793. *Journal of Archibald Menzies.* Honolulu, T.H., 1920. 199 pp., illus.

Mueller-Dumbois, D., and Lamoureux, C. H.
1967. *Soil-vegetation relationships in Hawaiian Kipukas.* Pacific Sci. 21(2):286-299, illus.

Neal, Marie C.
1948. *In gardens of Hawaii.* Bernice P. Bishop Museum Spec. Publ. 40. 805 pp., illus.

Nelson, Robert E.
1960. *Silk-oak in Hawaii--pest or potential timber?* U.S. Forest Serv. Misc. Paper 47. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 5 pp., illus.

Nelson, Robert E., and Hornibrook, E. M.
1962. *Commercial uses and volume of Hawaiian tree fern.* U.S. Forest Serv. Tech. Paper 73. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 10 pp., illus.

Nelson, Robert E., and Wheeler, Philip R.
1963. *Forest resources of Hawaii--1961.* Forestry Div., Dep. Land and Natur. Resources, State of Hawaii and Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr., Honolulu. 48 pp., illus.

Nelson, Robert E.
1965. *A record of forest plantings in Hawaii.* U.S. Forest Serv. Res. Bull. PSW-1. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 18 pp.

Nelson, Robert E., and Honda, Nobuo.
1966. *Plantation timber on the Island of Hawaii--1965.* U.S. Forest Serv. Res. Bull. PSW-3. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 52 pp., illus.

Perkins, R. C. L.
1903. *Introduction of birds into Hawaii.* The Hawaii. Planters' Monthly 22:143-144.

Richmond, G. B.
1965. *Naturalization of Java podocarpus in Hawaii rain forest.* U.S. Forest Serv. Res. Note PSW-76. Pacific SW. Forest & Range Exp. Sta., Berkeley, Calif. 5 pp., illus.

Ripperton, J. C.
1924. *The Hawaiian tree fern as a commercial source of starch.* Hawaii Agr. Exp. Sta. Bull. 53. 16 pp., illus.

Rock, Joseph F.
1913. *The indigenous trees of the Hawaiian Islands.* Published under patronage, Honolulu. 518 pp., illus.

Swezy, Otto H.
1954. *Forest entomology in Hawaii.* Bernice P. Bishop Museum Spec. Publ. 44, 266 pp., illus.

Territorial Planning Board.
1939. *An historic inventory of the physical, social and economic, and industrial resources of the Territory of Hawaii.* Ed. 2, 322 pp., illus.

Thrum, Thos. G.
1904. *The sandalwood trade of early Hawaii.* Hawaii. Almanac and Annual for 1905;43-74.

Walker, Thos. R.
1888. *Report of the committee on forestry.* The Hawaii. Planters' Monthly 7:519-522.

Wold, Myron L.
[n.d.] *Tree ferns of Hawaii--a nontechnical description of the three main species, their characteristics and use.* Hawaiian Fern-Wood, Ltd., Hilo, Hawaii. 6 pp.

GPO 975-903

U. S. D. A. FOREST SERVICE
RESOURCE BULLETIN
PSW - 9 1968

Plantation Timber on the Island of Molokai--1967

acific Southwest Forest and Range Experiment Station
orest Service, U. S. Department of Agriculture
erkeley, California 94701

and

Division of Forestry
Department of Land
and Natural Resources
State of Hawaii

Foreword

This report is one of a series about planted timber on the major islands in the State of Hawaii. Reports for the islands of Hawaii (1965), Kauai (1965), and Lanai (1966) have already been published. Summarized here are the results of an inventory of timber in planted forests on the island of Molokai. This inventory supplements the initial Forest Survey of the State completed in 1963. That survey indicated the importance of planted forests as a timber resource but provided no details. This bulletin reports: (a) location and acreage of each planted stand, (b) species composition and age of stand, (c) timber volume and quality, and (d) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, Director, Institute of Pacific Islands Forestry, Pacific Southwest Forest and Range Experiment Station. Nobuo Honda, Forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory and supervised the field work.

Many individuals aided in various phases of the survey. Special acknowledgment is due the field crew: Wesley Wong, Jr., Forester, and James Lindsey, Forest Ranger, both of the Hawaii Division of Forestry; and Kaipo Roberts, Forest Research Technician, Institute of Pacific Islands Forestry.

E. M. Hornibrook, retired, formerly in charge of Forest Survey, Pacific Southwest Forest and Range Experiment Station, and Russell K. LeBarron, former Forest Ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, Systems Analyst, Pacific Southwest Forest and Range Experiment Station, developed specifications for processing the data by electronic computers. The Computing Center at the University of Hawaii processed the data.

Tom K. Tagawa, State Forester, Albert J. MacDonald, District Forester, retired, and the late Max F. Landgraf, former State Forester, provided generous cooperation for the survey.

U.S. Forest Service research in Hawaii is conducted in cooperation with the Division of Forestry, Hawaii Department of Land and Natural Resources.

OXFORD: 228.7[(965)+524.61(965)+905.2(965)]+(965)905.2.
RETRIEVAL TERMS: Hawaii; Molokai; forest survey; plantations; forest resources; stand composition; stand age; stand volume.

Plantation Timber on the Island of Molokai—1967

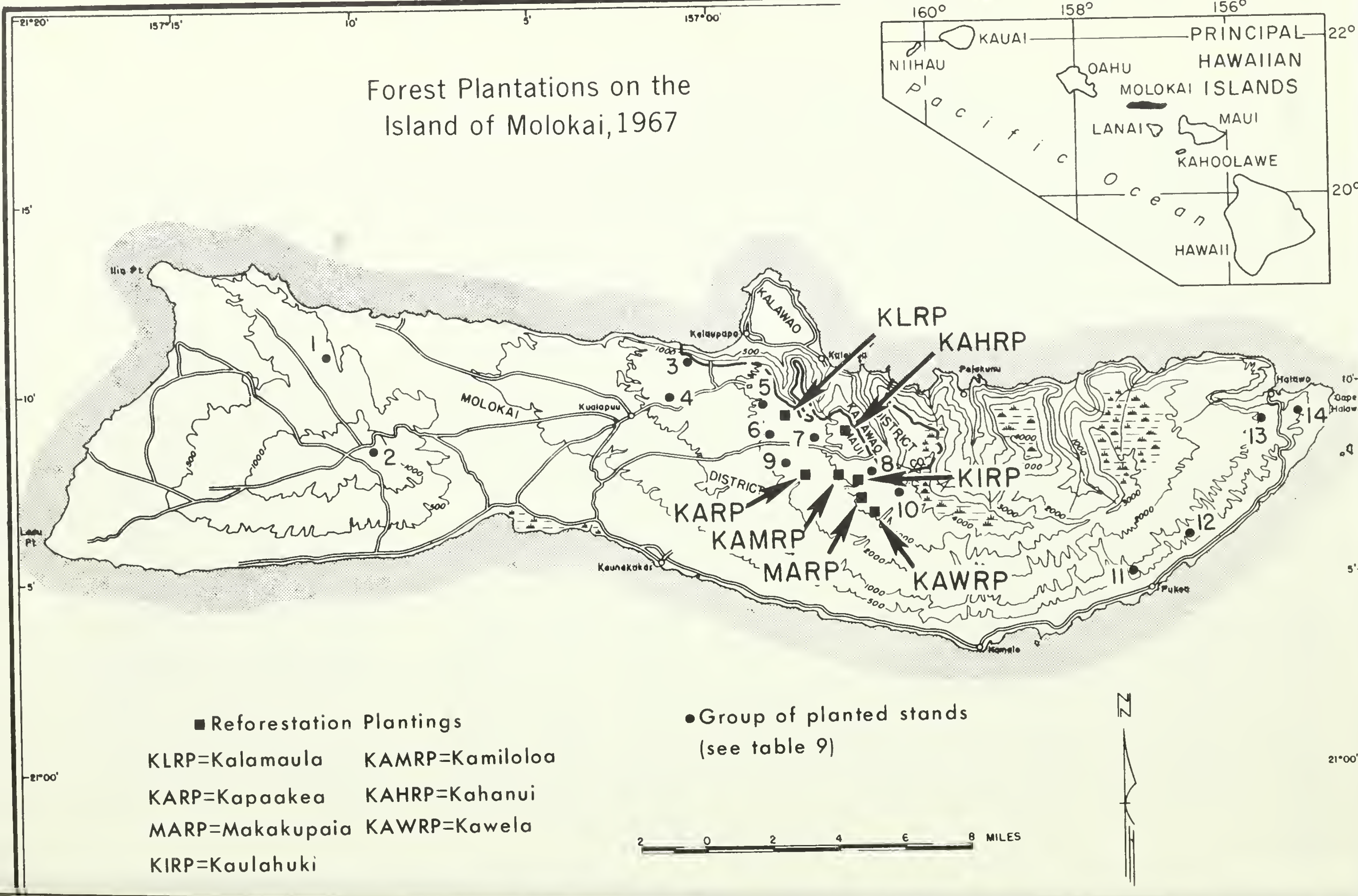
By

WESLEY H.C.WONG, Jr.   ROBERT E.NELSON   HERBERT L.WICK

CONTENTS

The Authors

WESLEY H. C. WONG, Jr., a native of Wailuku, Maui, received his bachelor's degree in forestry from Oregon State University in 1964. As timber survey forester for the Hawaii Division of Forestry, he has been assigned primarily to the forest inventory of the State. ROBERT E. NELSON directs the Station's Institute of Pacific Islands Forestry, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office. HERBERT L. WICK is working on mensuration problems and forest survey techniques. A native of Seattle, Washington, he earned a bachelor's and master's degree in forestry at the University of Washington. He worked 3 years in the Pacific Northwest with the Forest Service before joining the staff of the Institute of Pacific Islands Forestry in 1967.



Forest Plantations on the
Island of Molokai, 1967
PRINCIPAL HAWAIIAN ISLANDS
NIIHAU
KAUAI
OAHU
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
Pacific Ocean
160°
158°
156°
22°
20°
KLRP
KAHRP
KIRP
KARP
KAMRP
MARP
KAWRP
KALAWAO
KALAWAO
DISTRICT
MAUI
DISTRICT
MOLOKAI
Kalaupapa
Kualapuu
Kaunakakai
Kamalo
Pukoo
Halawa
Cape Halawa
Ilio Pt.
Laau Pt.
Pelekunu
1
2
3
4
5
6
7
8
9
10
11
12
13
14
■ Reforestation Plantings
KLRP=Kalamaula
KAMRP=Kamiloloa
KARP=Kapaakea
KAHRP=Kahanui
MARP=Makakupaia
KAWRP=Kawela
KIRP=Kaulahuki
●Group of planted stands
(see table 9)
2 0 2 4 6 8 MILES
21°20'
157°15'
10'
5'
157°00'
15'
10'
5'
21°00'

Molokai is fifth largest of the Hawaiian Islands. Its population totals about 6,000. Of volcanic origin, the island is some 38 miles long and about 6 to 8 miles wide, with a land area of 166,000 acres (259 square miles). Much of the eastern half has steep, rugged topography, with spectacular pali dominating the north coast. One peak, Kamakou, rises 4,970 feet; several others, above 3,500 feet. The mountains intercept the moisture-laden trade winds;rainfall exceeds 150 inches annually in places.

The western half of the island is of much gentler topography. Here and along the south coast are many areas of level or gently sloping arable lands. Annual rainfall is much less on these leeward lands--in places not even 25 inches. Because of limited water here, the eastern mountains are critically important watersheds and designated as Forest Reserve lands. The Forest Reserve includes public and private lands, administered by the State for management and protection of watersheds and other forest values.

About 18,000 acres of land on Molokai are cultivated, mostly for pineapple production. This is the primary commercial activity offering employment for residents, although truck farming and specialty crops are becoming increasingly important.

Cattle ranching is also a significant activity. Cattle graze on a large proportion of the land. Much of the grazed land is forested, but grazing is excluded from the Molokai Forest Reserve.

Hunting, fishing, and tourist services also contribute to the Island's economy. Apparently there is a potential to develop a much larger tourist industry.

The first inventory of Hawaii's forest resources found that 50 percent of the Island, or nearly 60,000 acres, is forest land[1] (fig. 1). Most of this acreage is noncommercial forest land,

---

[1]Nelson, Robert E., and Wheeler, Philip R. *Forest resources of Hawaii--1961.* Forestry Div., Dep. Land and Natural Resources, State of Hawaii, in cooperation with the Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr., 48 pp., illus. 1963.

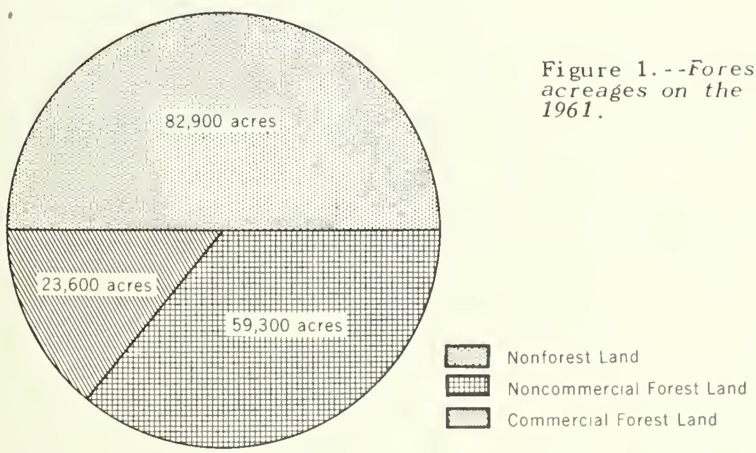


Figure 1.--*Forest and nonforest land acreages on the Island of Molokai, 1961.*

mainly in the lower, dry areas where kiawe(*Prosopis pallida*) and other brushy forest types predominate. Commercial forest land amounts to about 24,000 acres. These commercial forest lands, where rainfall and soils are adequate to support the growth of timber crops, are almost all in the Molokai Forest Reserve. However, the native forests which cover most of these commercial forest lands are not sawtimber stands and hold little prospect for commercial development.

Molokai has a small acreage of planted forests of introduced species. The plantings were started more than 50 years ago to improve watersheds and to develop a supply of fuelwood and fence posts. The more recent plantings have continued to emphasize improvement of watersheds, but timber values, wildlife, and recreation habitat improvement have become important considerations.

Because these forest plantations are an important resource, we have made a stand-by-stand inventory to obtain information about the acreage, species, timber volume and quality, and ownership of plantations. This report summarizes data compiled for each plantation stand.

Plantation Timber Resource

Area

Forest plantations on Molokai are concentrated mainly in the western part of the Molokai Forest Reserve between Puu o Kaeha and Palaau Park (see map and tables 8,9). Commercial forest plantations[2] total only about 2,100 acres in stands 2 acres and larger (tables 1-3, fig. 2). Of this acreage about 970 acres are sawtimber stands, and 1,130 acres are of seedling and sapling and pole-size stands. Noncommercial plantations total 530 acres, some of them on the arid slopes in western Molokai.

[2]See definitions of terms in Appendix.

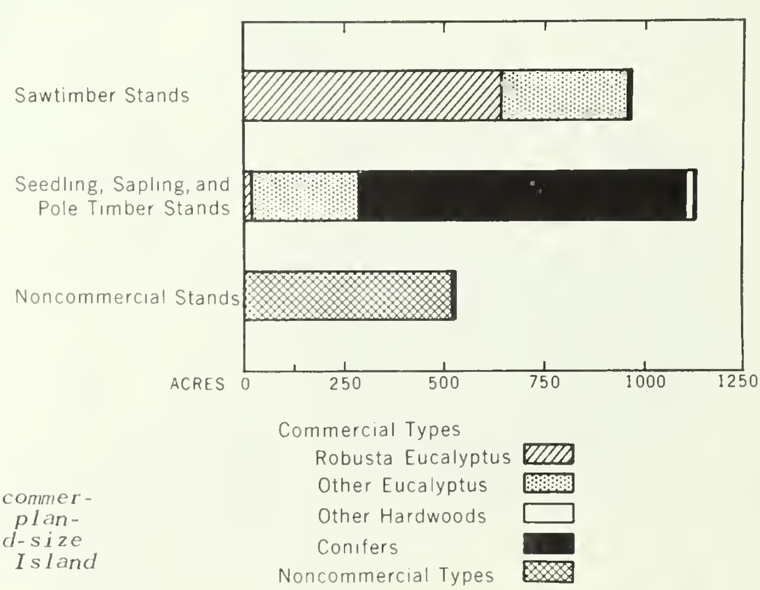


Figure 2.--*Acreage of commercial and noncommercial plantation stands, by stand-size class and forest type, Island of Molokai, 1967.*

About 99 percent of the acreage of sawtimber stands are eucalyptus; robusta eucalyptus sawtimber stands alone total about 640 acres. The only other sawtimber stand is a 7-acre plantation of sugi.

Plantings made during the past 10 to 15 years are still seedling and sapling or poletimber stands. During this period, pines, mainly slash pine and loblolly pine, have been used widely for reforestation--especially on the drier sites. As a result there are about 770 acres of young pine plantations. The area of young hardwood stands totals about 330 acres, mostly saligna eucalyptus.

The noncommercial plantations are mostly ironwood, Formosa koa, paper-bark, and Monterey cypress. But included are plantings of commercial species on sites not suited for producing timber crops, for example, robusta eucalyptus in west Molokai.

Timber Volume

The planted forests on Molokai contain about 12.6 million board feet of sawtimber (table 4). Essentially all of this volume of timber is in eucalypts. The volume of robusta eucalyptus alone amounts to about 10.4 million board feet, and the volume in other eucalypts totals some 2.2 million board feet. There is a small volume of conifer timber.

About 30 percent of the sawtimber volume, or some 3.8 million board feet, is in trees 19 inches to 29 inches d.b.h. (table 5). Six percent, or about 750,000 board feet, is in trees larger than 29 inches d.b.h. The balance, or about 8.1 million board feet, is in trees smaller than 19 inches d.b.h.

The total growing stock volume in planted sawtimber stands is about 3.2 million cubic feet. The growing stock volume in poletimber and sapling and seedling stands was not measured.

Wood in cull trees in the planted sawtimber stands totals about 84,000 cubic feet (table 6). The noncommercial plantations hold an additional and much greater volume of wood in cull trees, but these stands were not measured.

Ownership

The State of Hawaii owns about 52 percent of the acreage of forest plantations on the Island of Molokai (tables 1,2). Of the 2,627 acres tallied, the State owns 1,303 acres of commercial forest plantations and 66 acres of noncommercial plantations. Also publicly-owned is Hawaiian Homes Commission lands amounting to 71 acres of commercial plantations and 184 acres of noncommercial plantations. This land is State-owned, set aside, and administered by the Hawaiian Homes Commission for the benefit of people of Hawaiian ancestry. Private owners hold 729 acres of commercial plantations and 274 acres of noncommercial plantation types.

In volume, private owners hold a greater proportion of the timber because a substantial area of the State-owned plantations are younger seedling and sapling or poletimber stands (table 4). A large portion of the private stands are those in the older age groups with higher yields. Private ownership totals 59 percent,

Eucalyptus robusta compri
the bulk of the sawtimber
ume on Molokai. This 30-
old robusta stand (No. 40
averages nearly 20,000 bo
feet of sawtimber per acr

Slash pine is well adapted to dry sites and has been planted extensively to improve water shed cover, but in the future the stand will also provide timber.

Forests, such as this 30-year-old planting of Formosa koa, provide an attractive setting for outdoor activities.

Machine planting aids reforestation in Molokai Forest Reserve.

Water cascades down the pali, emphasizing the importance of the mountain watersheds.

Spectacular pali lands characterize Molokai's northeastern shore line where green cliffs sometimes plunge more than a thousand feet into deep valleys and the sea below.

In the days of sandalwood trade, trenches were shaped like a ship's hull to measure a load of the precious wood. Today, they are preserved as historic sites.

or about 7.4 million board feet, of the sawtimber volume. The State owns 33 percent or 4.2 million board feet. Hawaiian Homes owns 8 percent or nearly 1.0 million board feet.

Age of Stands

Forest plantations on Molokai are the result of reforestation efforts during three distinct periods--the early 1900's when the Forest Reserve was established; from 1935 to 1941 as part of the Civilian Conservation Corps program; and since 1956 as increased emphasis has been given to development and use of the forest resources. About 160 acres of commercial forest plantations are more than 30 years old (table 3). About 1,340 acres were planted during the CCC program. Some 1,130 acres have been reforested by the Hawaii Division of Forestry since 1949.

Stand Yields

Yields of sawtimber in the planted forests differ widely by stand age, species, site, history and condition of the stand,and other factors. The average yield of sawtimber in stands on Molokai is 13,000 board feet per acre. The highest stand average net volume measured was 56,000 board feet per acre in a stand of robusta eucalyptus about 60 years old (Stand #4057, table 8). Robusta eucalyptus stands averaged 16,000 board feet per acre. Saligna eucalyptus stands are generally much younger but averaged 32,000 board feet per acre.

Timber Quality

Saligna eucalyptus sawtimber is considered to be slightly better in quality than other species. This judgment is based on the proportion of volume in grades 1 and 2 factory lumber logs; 15 percent of the saligna sawtimber is in these two grades (table 7). But only about 12 percent of the robusta eucalyptus sawtimber volume is in grade 1 and 2 logs. Conifer species were not log-graded.

Opportunity for Industrial Development

Half of Molokai's land area, or about 83,000 acres, supports some kind of forest growth.[3] Although most of this land is noncommercial forest type there are about 24,000 acres that can produce timber crops. And, although the native forests are of little or no value for timber products, the growth of planted stands of introduced trees shows that the commercial forest lands have a high productive capacity for timber.

If managed, an average annual sawtimber growth rate of 1,000 board feet per acre can be expected from well stocked forests on good sites. Thus, if only half of the 24,000 acres of presently little-used and unmanaged commercial forest land were planted to adapted timber species, production of timber would amount to about 10 million board feet annually in about 30 years. Such a timber resource could be an adequate base to support a small local milling industry.

---

[3] Nelson and Wheeler. Op. cit.

Recent reforestation efforts by the State are in part an attempt to capitalize on this potential. Species are being selected with consideration for wood qualities and adaptability to specific sites. Plantings are made in large blocks on non-stocked lands. Reforestation efforts should be continued to bring a much greater forest area under management. The amount of planting accomplished during the next 10 years will determine in large part the amount of harvestable timber that might be available 30 to 40 years from now as a base for a milling industry. The acreage and volume of timber in planted forests now are too small to sustain a significant milling industry on the island.

Multiple Values of Forests

Forest plantations provide many values besides timber. Especially on Molokai, their value for watershed improvement, for shelterbelts, and for recreation habitat may far exceed the value of timber harvests. They can also provide improved wildlife habitat. Christmas trees can be produced in much greater numbers for local use. Planted forests of introduced trees provide the most attractive and heavily used forest recreation sites on the island. They improve the esthetics of the land--on-site and from a distance. Some of the younger pine plantations established for watershed improvement and erosion control will become increasingly important for recreation.

In the western part of the Island, shelterbelts are needed to control wind and erosion. Species selection and establishment of plantings are difficult on these dry sites. But here too, once established, the forest affords a recreation site, better wildlife habitat, and an esthetic improvement in the landscape.

These multiple benefits from planted forests accrue continuously year after year. In addition, timber can be harvested periodically without detracting from and often enhancing the recreation and watershed values. The potential for improving watershed, scenic, recreation, and wildlife values, as well as to grow timber, is amply demonstrated in the existing plantations. Public land managers and private owners should not overlook the opportunity to create a multiple-use resource on thousands of acres of these little-used lands.

Appendix

Definitions

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground.

Commercial forest land: Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.

Noncommercial forest land: (a) *Productive-reserved* forest land withdrawn from timber use through statute or administrative regulation, and (b) *unproductive* forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of growing space is occupied by planted trees (introduced species in this report), regardless of native species predominance.

Commercial forest plantation: A plantation of commercial tree species on commercial forest land.

Noncommercial forest plantation: A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuel wood or fence posts are excluded. The following were tallied on plots:

Scientific Name	*Common Name*
Araucaria excelsa	Norfolk-Island-pine
Cryptomeria japonica	sugi
Eucalyptus citriodora	lemon-gum eucalyptus
Eucalyptus microcorys	tallowwood eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus sideroxylon	red-ironbark eucalyptus
Eucalyptus spp.	unidentified eucalyptus

Other frequently planted commercial tree species, not tallied on plots:

Scientific Name	*Common Name*
Acacia melanoxylon	blackwood acacia
Chamaecyparis lawsoniana	Port-Orford-cedar
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Pinus elliottii	slash pine
Pinus pinaster	cluster pine
Pinus radiata	Monterey pine
Pinus spp.	hybrid pines
Pinus taeda	loblolly pine
Syncarpia glomulifera	turpentine-tree
Thuja plicata	western redcedar
Tristania conferta	brushbox

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following were tallied on plots:

Scientific Name	*Common Name*
Acacia decurrens	black-wattle acacia
Aleurites moluccana	kukui (candlenut-tree)
Casuarina spp.	ironwoods
Cupressus macrocarpa	Monterey cypress
Ficus spp.	unidentified figs

Other commonly planted noncommercial species, not tallied on plots:

Scientific name	*Common Name*
Acacia confusa	Formosa koa
Eucalyptus spp.	unidentified eucalyptus
Juniperus sp.	juniper
Melaleuca leucadendron.	paper-bark

Hardwoods: Dicotyledonous trees; usually broadleaved.

Conifers: Coniferous trees; usually evergreen; having needle or scale-like leaves. Also generally known as softwoods.

Forest types: Forests which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type, ohia type, or tropical ash type. Otherwise or for grouping of area statistics they are designated:

Eucalyptus: Planted stands predominantly of eucalyptus species.

Hardwood: Planted stands predominantly of hardwoods other than the eucalypts.

Conifer: Planted forests predominantly of conifers.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

Sawtimber trees: Live trees of commercial species of at least 11.0 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.

Poletimber trees: Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.

Saplings and seedlings: Live trees of commercial species between 1.0 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Sawtimber: Wood in trees defined as sawtimber trees.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections: $V = 0.905\ (0.22D^2 - 0.71D)$, where D is log diameter at small end, inside bark.

Sawtimber volume: The net volume of the saw-log portion of sawtimber trees, in board feet, International 1/4-inch rule.

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable sawlog cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5.0 inches d.b.h. or larger, from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches.

Stand-Class Sizes

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing-stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing-stock trees.

Nonstocked: Commercial forest lands less than 10 percent stocked with growing-stock trees.

Miscellaneous

Diameter breast height (d.b.h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as sawlogs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value of lumber the logs will yield. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[4] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, these are usually inherent in a species.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand by plantation stand. First, individ-

[4]U.S. Forest Products Laboratory. *Hardwood log grades for standard lumber--proposals and results.* U.S.D.A. Forest Serv. Forest Prod. Lab. Report 1737, 15 pp., illus. 1953.

ual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured from the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared computer program. Tree measurements were converted to meaningful volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreage of the stand. The computer output consisted of tabular data for each stand and summaries of stand data by forest reserves. Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands and added to the computer processed data.

The accuracy goal for this inventory was ± 20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. The reliability of estimates for each forest reserve, based on measured stands only, are shown below. Two chances out of three the estimated volume does not vary from the actual by greater than the sampling error indicated.

Forest Reserve	Total volume (MBF)	Sampling error (percent)
Molokai	10,450	7.5
Palaau Park	1,325	20.5
Outside Forest Reserve	350	15.2
	12,125	
Observation Stands		
Molokai	363	(*)
Palaau Park	56	(*)
Outside Forest Reserve	56	(*)
	475	
Total volume	12,600	

* Sampling error not available.

Table 1.--Area of forest plantations by forest type, forest reserve, and ownership,[1/] Island of Molokai, 1967

Forest reserve and ownership	Commercial forest types			Total commercial types	Total noncommercial types	Total all types
	Eucalyptus	Hardwoods	Conifers			
	Acres					
Molokai Forest Reserve						
State	661	13	629	1,303	75	1,378
Private	394	17	177	588	--	588
Total	1,055	30	806	1,891	75	1,966
Palaau Park						
Hawaiian Homes	61	--	--	61	184	245
Private	39	--	--	39	32	71
Total	100	--	--	100	216	316
Outside Forest Reserve						
Hawaiian Homes	10	--	--	10	--	10
Private	102	--	--	102	242	344
Total	112	--	--	112	242	354
Island Totals						
State	661	13	629	1,303	75	1,378
Private	535	17	177	729	274	1,003
Hawaiian Homes	71	--	--	71	184	255
Total	1,267	30	806	2,103	533	2,636

1/ Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand, the ownership designation may be in error, although over-all ownership statistics are probably not greatly affected by this kind of error.

Table 2.--Area of forest plantations by forest type, ownership class, and stand-size class, Island of Molokai, 1967

Stand-size class and forest type	Ownership class: State	Ownership class: Private	Ownership class: Hawaiian Homes	All ownerships
	Acres			
Commercial types:				
Sawtimber stands				
Robusta eucalyptus	307	276	61	644
Saligna eucalyptus	21	6	--	27
Other eucalyptus 1/	66	227	--	293
Conifer 2/	--	7	--	7
Total	394	516	61	971
Poletimber stands				
Robusta eucalyptus	--	10	10	20
Conifer 2/	3	--	--	3
Total	3	10	10	23
Seedling & sapling stands				
Saligna eucalyptus	167	11	--	178
Pines 3/	602	170	--	772
Other eucalyptus 1/	100	5	--	105
Other conifer 2/	24	--	--	24
Hardwood 4/	13	17	--	30
Total	906	203	--	1,109
Total commercial	1,303	729	71	2,103
Noncommercial types:				
Eucalyptus	--	54	--	54
Ironwood	5	89	77	171
Formosa koa	--	--	54	54
Paper-bark	34	--	8	42
Other hardwood 5/	--	119	31	150
Conifer 6/	36	12	14	62
Total noncommercial	75	274	184	533
Total forest plantation	1,378	1,003	255	2,636

1/ Includes blackbutt eucalyptus, tallowwood eucalyptus, lemon-gum eucalyptus, red-ironbark eucalyptus, and unidentified eucalyptus.

2/ Includes sugi, western red-cedar, and Port-Orford cedar, but excludes pines.

3/ Conifer forest type includes: Monterey pine, loblolly pine, slash pine, cluster pine, and hybrid pines.

4/ Includes silk-oak, ash, and blackwood.

5/ Includes mixed stands of ironwood, paper-bark, and Formosa koa.

6/ Juniper and Monterey cypress.

Table 3.--Area of forest plantations by ownership class, forest type, and period planted, Island of Molokai, 1967

Dwnership class and forest type	Period of planting 1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1965	1966-1967	Total
	Acres							
te:								
bbusta eucalyptus	--	--	--	307	--	--	--	307
aligna eucalyptus	--	--	--	21	--	167	--	188
her eucalyptus 1/	--	--	--	66	--	100	--	166
ackwood acacia	--	--	--	--	--	13	--	13
ronwood	--	--	--	5	--	--	--	5
aper-bark	--	--	--	34	--	--	--	34
onifer 2/	--	--	--	39	291	324	11	665
Total	--	--	--	472	291	604	11	1,378
vate:								
bbusta eucalyptus	49	--	10	217	10	--	--	286
aligna eucalyptus	--	--	--	6	--	11	--	17
her eucalyptus 1/	--	--	43	238	3	2	--	286
ronwood	--	--	62	27	--	--	--	89
her hardwood 3/	--	--	--	119	16	1	--	136
onifer 2/	--	--	--	19	33	130	7	189
Total	49	--	115	626	62	144	7	1,003
aiian Homes:								
obusta eucalyptus	--	--	--	61	10	--	--	71
ronwood	--	--	--	77	--	--	--	77
aper-bark	--	--	--	8	--	--	--	8
her hardwood 3/	--	--	--	85	--	--	--	85
onifer 2/	--	--	--	14	--	--	--	14
Total	--	--	--	245	10	--	--	255
al forest antations	49	--	115	1,343	363	748	18	2,636

1/ Includes both commercial and noncommercial eucalypts other than robusta alyptus and saligna eucalyptus.

2/ Includes both commercial and noncommercial conifer species.

3/ Includes both commercial and noncommercial hardwoods other than blackwood cia, eucalyptus, ironwood, and paper-bark.

Table 4.--Volume of sawtimber and growing stock by species and ownership class[1] in planted sawtimber stands, Island of Molokai, 1967

Species	State	Hawaiian Homes	Private	All Ownerships
	Thousand board feet[2]			
Blackbutt eucalyptus	29	--	101	130
Eucalyptus spp.	129	10	741	880
Lemon-gum eucalyptus	--	--	7	7
Red-ironbark eucalyptus	--	--	58	58
Robusta eucalyptus	3,416	956	6,038	10,410
Saligna eucalyptus	594	--	259	853
Tallowwood eucalyptus	5	--	216	221
Norfolk-Island-pine	9	--	15	24
Sugi	--	--	17	17
Total	4,182	966	7,452	12,600
	Thousand cubic feet			
Blackbutt eucalyptus	5	--	23	28
Eucalyptus spp.	42	3	227	272
Lemon-gum eucalyptus	--	--	2	2
Red-ironbark eucalyptus	--	--	15	15
Robusta eucalyptus	1,016	261	1,326	2,603
Saligna eucalyptus	132	1	49	182
Tallowwood eucalyptus	2	--	60	62
Norfolk-Island-pine	2	--	2	4
Sugi	--	--	8	8
Total	1,199	265	1,712	3,176

1/ See footnote 1, Table 1.
2/ International 1/4-inch rule.

Table 5.--Volume of sawtimber and growing stock in planted sawtimber stands by species group and diameter class, Island of Molokai, 1967

Species group	Tree diameter class (inches at breast height)								
	All classes	5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0-plus
	Thousand board feet 1/								
Robusta eucalyptus	10,410	--	1,154	1,978	1,894	1,643	3,018	686	37
Saligna eucalyptus	853	--	79	133	157	150	320	14	--
Other eucalyptus 2/	1,296	--	108	244	241	194	493	16	--
Conifer 3/	41	--	5	8	19	--	9	--	--
Total	12,600	--	1,346	2,363	2,311	1,987	3,840	716	37
	Thousand cubic feet								
Robusta eucalyptus	2,603	204	469	538	408	325	541	111	7
Saligna eucalyptus	182	14	28	30	29	27	52	2	--
Other eucalyptus 2/	379	40	42	76	65	47	91	18	--
Conifer 3/	12	3	2	2	3	2	--	--	--
Total	3,176	261	541	646	505	401	684	131	7

1/ International 1/4-inch rule.

2/ Includes blackbutt eucalyptus, lemon-gum eucalyptus, red-ironbark eucalyptus, tallowwood eucalyptus and unidentified eucalypts.

3/ Norfolk-Island-pine and sugi.

Table 6.--Volume of cull trees in planted sawtimber stands by forest reserve and species group, Island of Molokai, 1967

Species group	Forest reserve: Molokai	Forest reserve: Palaau Park	Forest reserve: Outside reserve	Island total
	Thousand cubic feet			
Robusta eucalyptus	54	8	4	66
Saligna eucalyptus	1	-	-	1
Other eucalyptus 1/	9	-	4	13
Conifer 2/	1	-	-	1
Other hardwood 3/	2	1	-	3
Total	67	9	8	84

1/ Includes blackbutt eucalyptus, red-ironbark eucalyptus, tallowwood eucalyptus, and unidentified eucalypts.

2/ Sugi, and Monterey cypress.

3/ Black-wattle acacia, kukui, *Casuarina* spp. and *Ficus* spp.

Table 7.--Sawtimber volume in planted sawtimber stands by ownership class, species group, and log grade,[1] Island of Molokai, 1967

Ownership class and species group	All grades	Factory lumber logs			Tie and timber logs	Softwood species[2]
		Grade 1	Grade 2	Grade 3	Grade 4	
	Thousand board feet[3]					
State:						
Robusta eucalyptus	3,416	6	10	104	3,296	--
Saligna eucalyptus	595	39	28	126	402	--
Other eucalyptus [4]	162	3	6	30	123	--
Conifer [5]	9	--	--	--	--	9
Total	4,182	48	44	260	3,821	9
Hawaiian Homes:						
Robusta eucalyptus	956	14	2	131	809	--
Other eucalyptus [4]	10	--	--	--	10	--
Total	966	14	2	131	819	--
Private:						
Robusta eucalyptus	6,038	790	374	769	4,105	--
Saligna eucalyptus	259	32	28	65	134	--
Other eucalyptus [4]	1,123	29	45	117	932	--
Conifer [5]	32	--	--	--	--	32
Total	7,452	851	447	951	5,171	32
All Ownerships:						
Robusta eucalyptus	10,410	810	386	1,004	8,210	--
Saligna eucalyptus	853	71	56	191	535	--
Other eucalyptus [4]	1,296	32	51	147	1,066	--
Conifer [5]	41	--	--	--	--	41
Total	12,600	913	493	1,342	9,811	41

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ Commercial conifer species were not graded.
3/ International 1/4-inch rule.
4/ Includes blackbutt eucalyptus, lemon-gum eucalyptus, red-ironbark eucalyptus, tallowwood eucalyptus, and *Eucalyptus* spp.
5/ Norfolk-Island-pine and sugi.

Table 8.--Listing of individual stands and plantings with forest type, ownership, area, and volume, Island of Molokai, 1967

FORESTS PLANTED BEFORE 1949

Stand No.	Forest type	Owner	Acres	Total stand volume
				Thousand board feet
4001	Eucalyptus[1/]	Private	11	(2/)
4002	Juniper	Private	7	(2/)
4003	Eucalyptus	Private	43	(3/)
4004	"	Private	9	87
4005	"	State	13	40
4006	Monterey cypress	State	5	(2/)
4007	" "	State	5	(2/)
4008	Saligna eucalyptus	State	8	143
4009	Robusta eucalyptus	State	24	334
4010	Ironwood	Private	29	(2/)
4011	Robusta eucalyptus	Private	4	12
4012	Ironwood	Private	27	(2/)
4013	Hardwood	Private	119	(2/)
4014	Ironwood	Hawaiian Homes	77	(2/)
4015	Monterey cypress	Hawaiian Homes	3	(2/)
4016	Formosa koa	Hawaiian Homes	15	(2/)
4017	Robusta eucalyptus	Hawaiian Homes	25	455
4018	" "	Private	2	6
4019	Formosa koa	Hawaiian Homes	39	(2/)
4020	Monterey cypress	Hawaiian Homes	11	(2/)
4021	Paper-bark	Hawaiian Homes	8	(2/)
4022	Ironwood	State	5	(2/)
4023	Hardwood	Hawaiian Homes	31	(2/)
4024	Robusta eucalyptus	Hawaiian Homes	5	90
4025	Eucalyptus	Private	3	56
4026	Robusta eucalyptus	Private	4	4
4027	Eucalyptus	Private	9	169
4028	Monterey cypress	Private	5	(2/)
4029	Ironwood	Private	8	(2/)
4030	Robusta eucalyptus	State	15	184

See footnotes at end of Table.

Table 8, continued

FORESTS PLANTED BEFORE 1949

Stand No.	Forest type	Owner	Acres	Total stand volume
				Thousand board feet
4031	Robusta eucalyptus	State	10	85
4032	Paper-bark	State	7	(2/)
4033	Sugi	State	3	(4/)
4034	Paper-bark	State	27	(2/)
4035	Robusta eucalyptus	State	15	183
4036	Monterey cypress	State	3	(2/)
4037	Saligna eucalyptus	State	3	52
4038	" "	State	7	122
4039	" "	State	3	52
4040	Robusta eucalyptus	State	3	37
4041	Robusta eucalyptus	State	2	24
4042	Monterey cypress	State	2	(2/)
4043	Robusta eucalyptus	Private	11	137
4044	Saligna eucalyptus	Private	6	148
4045	Robusta eucalyptus	Private	19	522
4046	Eucalyptus	Private	8	66
4047	"	Private	26	52
4048	"	Private	17	91
4049	"	Private	4	11
4050	"	State	45	50
4051	Eucalyptus	State	2	4
4052	Robusta eucalyptus	State	2	2
4053	Eucalyptus	State	3	6
4054	Robusta eucalyptus	Private	27	190
4055	" "	Hawaiian Homes	31	421
4056	Robusta eucalyptus	Private	20	610
4057	" "	Private	29	1625
4058	" "	State	35	511
4059	" "	State	7	65
4060	" "	Hawaiian Homes	10	(4/)
4061	Robusta eucalyptus	State	17	180
4062	" "	Private	10	(4/)
4063	Eucalyptus	Private	7	36
4064	"	Private	9	23
4065	"	Private	19	90

See footnotes at end of Table.

Table 8, continued

FORESTS PLANTED BEFORE 1949

Stand No.	Forest type	Owner	Acres	Total stand volume
				Thousand board feet
4066	Eucalyptus	Private	34	201
4067	Robusta eucalyptus	Private	11	165
4068	Eucalyptus	Private	21	193
4069	"	Private	13	74
4070	"	State	20	84
4071	Robusta eucalyptus	Private	16	325
4072	" "	Private	8	137
4073	" "	Private	34	1120
4074	Sugi	Private	7	33
4075	Eucalyptus	Private	11	25
4076	Robusta eucalyptus	State	30	625
4077	" "	State	4	8
4078	" "	State	34	270
4079	Ironwood	Private	8	(2/)
4080	"	Private	6	(2/)
4081	Ironwood	Private	4	(2/)
4082	Robusta eucalyptus	Private	13	233
4083	Tallowwood eucalyptus	Private	2	36
4084	Robusta eucalyptus	Private	19	280
4085	" "	Private	32	531
4086	Ironwood	Private	4	(2/)
4087	"	Private	3	(2/)
4088	Robusta eucalyptus	Private	3	6
4089	" "	State	9	119
4090	Eucalyptus	State	8	83
4091	Robusta eucalyptus	State	8	87
4092	Monterey cypress	State	2	(2/)
4093	" "	State	2	(2/)
4094	Eucalyptus	State	14	258
4095	"	State	3	55
4096	Robusta eucalyptus	State	10	61
4097	Eucalyptus	Private	39	105
4098	Monterey cypress	State	8	(2/)
4099	Robusta eucalyptus	State	6	57
4100	" "	Private	4	11

See footnotes at end of Table.

Table 8, continued

FORESTS PLANTED BEFORE 1949

Stand No.	Forest type	Owner	Acres	Total stand volume
				Thousand board feet
4101	Eucalyptus	Private	2	5
4102	"	State	3	8
4103	Robusta eucalyptus	State	14	247
4104	" "	State	5	22
4105	" "	State	2	5
4106	Robusta eucalyptus	State	8	83
4107	" "	State	2	35
4108	" "	Private	2	5
4109	" "	Private	2	6
4110	" "	Private	4	11
4111	Robusta eucalyptus	Private	2	5
4112	" "	Private	2	6
4113	" "	Private	2	5
4114	Conifer	State	9	(2/)
	Total	--	1,527	12,600

AREAS REFORESTED 1949-67 5/

	Kawela area:			
--	Pine	Private	86	(4/)
--	Eucalyptus	Private	17	(4/)
--	Hardwood 6/	Private	5	(4/)
	Total Kawela	--	108	--
	Makakupaia area:			
--	Pine	State	237	(4/)
--	Pine	Private	76	(4/)
	Total Makakupaia	--	313	--
	Kaulahuki area:			
--	Pine	State	94	(4/)
--	Pine	Private	4	(4/)
	Total Kaulahuki	--	98	--

See footnotes at end of Table.

Table 8, continued

AREAS REFORESTED 1949-67 5/

Stand No.	Forest type	Owner	Acres	Total stand volume
				Thousand board feet
	Kamiloloa area:			
--	Pine	State	91	(4/)
	Total Kamiloloa	--	91	--
	Kapaakea area:			
--	Pine	State	178	(4/)
--	Other conifer 7/	State	5	(4/)
	Total Kapaakea	--	183	--
	Kahanui area:			
--	Saligna eucalyptus	State	129	(4/)
--	Eucalyptus	State	100	(4/)
--	Conifer	State	19	(4/)
--	Hardwood	State	13	(4/)
	Total Kahanui	--	261	--
	Kalamaula area:			
--	Pine	State	2	(4/)
--	Pine	Private	4	(4/)
--	Saligna eucalyptus	State	38	(4/)
--	Saligna eucalyptus	Private	11	(4/)
	Total Kalamaula	--	55	--
	Total reforestation area	--	1,109	
	Total all forest plantations		2,636	

1/ Eucalyptus stand of 2 or more species or unidentified species.

2/ Noncommercial plantation type.

3/ Commercial species on noncommercial land.

4/ Poletimber or seedling and sapling stands.

5/ No stand number assigned.

6/ Includes ash and silk-oak.

7/ Includes western redcedar and Port-Orford-cedar.

Table 9.--Identity of individual plantation stands in the groups shown on the map "Forest Plantations on the Island of Molokai, 1967"[1/]

Group Stand No.	Individual Stand No.
1	4013
2	4001-03
3	4012, 14-17, 19-21, 23-25, 27-28, 54, 55
4	4010, 11, 18
5	4008, 9, 30-42
6	4052, 71-78, 22, 52, 60-69, 46, 47, 58
7	4056, 57, 82-85, 05-07, 89-91, 43-45
8	4092-96, 98, 99, 4102-07
9	4070, 04, 59, 97, 48-51, 53
10	4110-13
11	4109
12	4100, 01, 08, 4088
13	4087
14	4026, 29, 79-81, 86

1/ Unnumbered stands on the map are identified by symbols as follows:

MARP --Makakupaia reforestation planting, 1949-1967, includes seedling, sapling, and poletimber.

KARP --Kapaakea reforestation planting, 1949-1967 includes seedling, sapling, and poletimber.

KIRP --Kaulahuki reforestation planting, 1949-1967 includes seedling, sapling, and poletimber.

KAHRP--Kahanui reforestation planting, 1949-1967 includes seedling, sapling, and poletimber.

KLRP --Kalamaula reforestation planting, 1949-1967 includes seedling, sapling, and poletimber.

KAWRP--Kawela reforestation planting, 1949-1967 includes seedling, sapling, and poletimber.

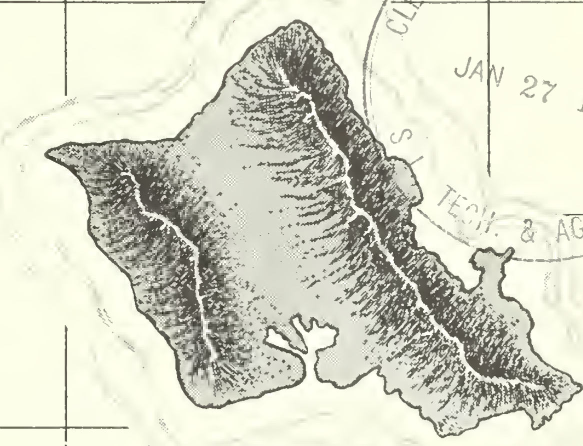
KAMRP--Kamiloloa reforestation planting, 1949-1967 includes seedling, sampling, and poletimber.

GPO 976-450

U. S. D.A. FOREST SERVICE
RESOURCE BULLETIN
PSW-10 1968

antation Timber

n the Island of Oahu--1966



Pacific Southwest Forest and Range
Experiment Station, Forest Service,
U.S. Department of Agriculture,
Berkeley, California 94701

and

Division of Forestry,
Department of Land
and Natural Resources,
State of Hawaii,
Honolulu, Hawaii 96813

Plantation Timber on the Island of Oahu--1966

Robert E. Nelson Wesley H.C. Wong, Jr. Herbert L. Wick

Contents

The Authors

ROBERT E. NELSON directs the Station's Institute of Pacific Islands Forestry, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office. WESLEY H.C. WONG, Jr., a native of Wailuku, Maui, received his bachelor's degree in forestry from Oregon State University in 1964. As timber survey forester for the Hawaii Division of Forestry, he has been assigned primarily to the forest inventory of the State. HERBERT L. WICK is working on mensuration problems and forest survey techniques. A native of Seattle, Washington, he earned a bachelor's and master's degree in forestry at the University of Washington. He worked 3 years in the Pacific Northwest with the Forest Service before joining the staff of the Institute of Pacific Islands Forestry in 1967.

Foreword

This report is one of a series about planted forests on major islands in the State of Hawaii. Reports have been published for the islands of Hawaii (1966), Kauai (1967), Lanai (1967), and Molokai (1968). Summarized here are the results of a survey of timber in planted forests on the Island of Oahu. This inventory supplements the initial Forest Survey of the State completed in 1963. That survey indicated the importance of planted forests as a timber resource, but provided no details. This bulletin reports: (a) location and acreage of each planted stand, (b) species composition and age of stand, (c) timber volume and quality, and (d) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, Director, Institute of Pacific Islands Forestry, Pacific Southwest Forest and Range Experiment Station. Nobuo Honda, forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory and supervised the field work.

In 1966, responsibility for supervision of the Forest Survey in the Pacific Coast States and Hawaii was shifted to the Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, but field work in Hawaii will continue to be a joint effort of the Hawaii Division of Forestry and the Pacific Southwest Station.

Many individuals aided in various phases of the survey. Special acknowledgment is due to the field crew: Forester, Wesley H. C. Wong of the Hawaii Division of Forestry and Forestry Research Technician Kaipo Roberts of the U.S. Forest Service.

E. M. Hornibrook, formerly in charge of the Forest Survey, Pacific Southwest Station, and Russell K. LeBarron, former Forest Ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, Systems Analyst, Pacific Southwest Station, developed specifications for processing data by electronic computers. The Computing Center at the University of Hawaii processed the data.

Tom K. Tagawa, Hawaii State Forester, the late Max F. Landgraf, former State Forester, Albert J. MacDonald, District Forester (retired), and Forest Rangers Teruo Yoshioka and George Nozawa provided generous cooperation in the conduct of the survey.

U.S. Forest Service research in Hawaii is conducted in cooperation with the Division of Forestry, Hawaii Department of Lands and Natural Resources.

OXFORD: (969):228.7--05. *RETRIEVAL TERMS:* planted forests; surveys; stand composition; stand volume; forest ownership; Hawaii (Oahu).

Oahu ranks third in size (604 square miles) but first in population (650,000) among the islands of Hawaii. About 8 of every 10 persons in the State live here--chiefly in the metropolitan Honolulu-Waikiki-Pearl Harbor complex. Centered on Oahu are Hawaii's chief business, military, and tourist activities. Next in importance to these three activities comes agriculture --the island produces 60 percent of pineapples, 48 percent of the diversified crops and livestock products, and 19 percent of the sugar in the State.[1]

Formed by volcanic action, much of Oahu is marked by steep rugged topography. On the westerly side of the island, Mount Kaala in the Waianae Range rises to 4,025 feet. To the east, several mountains in the long narrow Koolau Range rise above 2,700 feet--one to 3,150 feet.

There are also large areas of level or gently sloping lands, especially the expansive Wahiawa plain which separates the Waianae and Koolau ranges. A narrow, irregular and interrupted coastal plain almost completely skirts the island.

In this island setting, economic and social activities depend on the kind and extent of natural resources. These activities in turn have a marked impact on natural resources. And in this setting, forest lands are becoming increasingly important because of their multiple values.

More than half--55 percent--of Oahu is forested.[2] Of the 211,000 acres, 97,000 acres are commercial forest land holding about 52 million board feet of sawtimber (figs. 1,2), and about 114,000 acres are noncommercial forest land. In addition, the island has about 10,000 acres of nonforest rockland and pali in the Waianae and Koolau ranges. Land in Forest and Water Reserve status amounts to 123,000 acres, mostly rugged and mountainous. The Reserves are public and private lands administered by the State for the management and protection of watershed and other forest values.

---

[1] Bank of Hawaii. *Economy of Hawaii, 1967*. Annual Economic Report, August 1967. 47 pp., illus.

[2] Nelson, Robert E., and Wheeler, Philip R. *Forest Resources of Hawaii--1961*. Forestry Div., Dep. Land and Natur. Resources, State of Hawaii, in cooperation with Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr., 48 pp., illus. 1963.

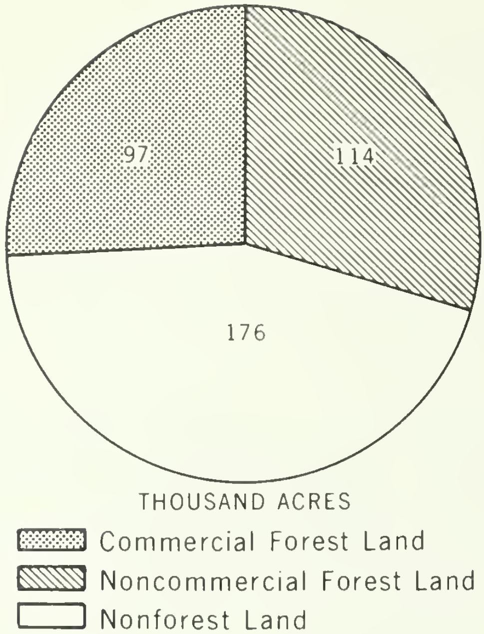


Figure 1.--*Forest and nonforest land acreages on the Island of Oahu, Hawaii, 1961. (Adjusted to 1967 total land area figure.)*

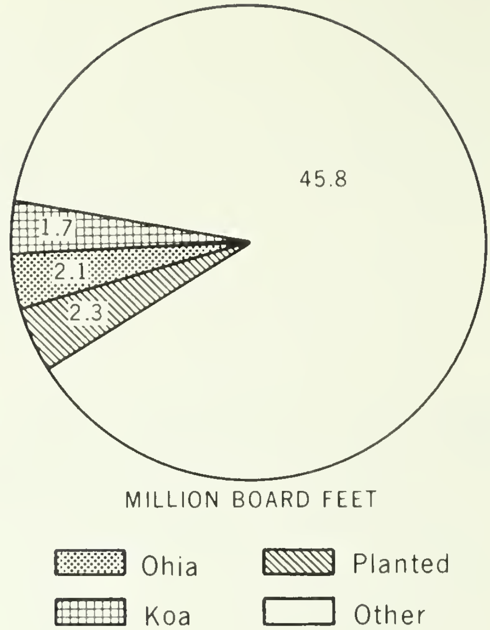


Figure 2.--*Sawtimber volumes on the Island of Oahu. (The figure for planted timber is based on 1966 data; other figures are from 1961 data.)*

Most of the forest acreage is native or naturalized types, with little volume of sawtimber. Noncommercial forest or brush types occupy nearly 80,000 acres of the commercial forest land. In the first Forest Survey of Hawaii, only about 12,000 acres of the ohia (*Metrosideros collina*), koa (*Acacia koa*),[3] and naturalized silk-oak (*Grevillea robusta*) or other naturalized types were considered commercial types.[4] Sawtimber stocking in these stands averages only about 500 board feet per acre, for a total of about 6 million board feet.

Forest plantings were started on Oahu in the late 1800's to develop a supply of fuelwood, fenceposts, and other products, and to enhance watershed conditions.[5,6] Reforestation efforts of the Territorial Division of Forestry to revegetate watersheds were greatly expanded during the late 1930's with the aid of the Civilian Conservation Corps.

The planted forests on Oahu--even though small in acreage--now hold several times more volume of sawtimber than do the native forests. They yield more timber than the native stands and the timber is generally of better quality. The plantation vol-

---

[3]A small acreage of planted koa forest is included in the over-all acreage of native forest type because of the difficulty of differentiation. Generally, these planted koa forests have not developed into sawtimber stands.

[4]Nelson and Wheeler, op. cit.

[5]Lubker, F. *The wattle trees.* The Planters' Monthly (Hawaii) 6(9): 229-230. 1886.

[6]Walker, Thomas R. *Report of committee on forestry.* The Planters' Monthly (Hawaii) 6(11): 531-533. 1887.

ume totals only about 46 million board feet, but has potential for industrial use. Most of the volume is accessible.

In 1966, we started a stand-by-stand inventory of plantation timber to obtain detailed information on acreage, volume and quality of timber, and ownership. This report summarizes data compiled for each stand.

Forest Plantation Resources

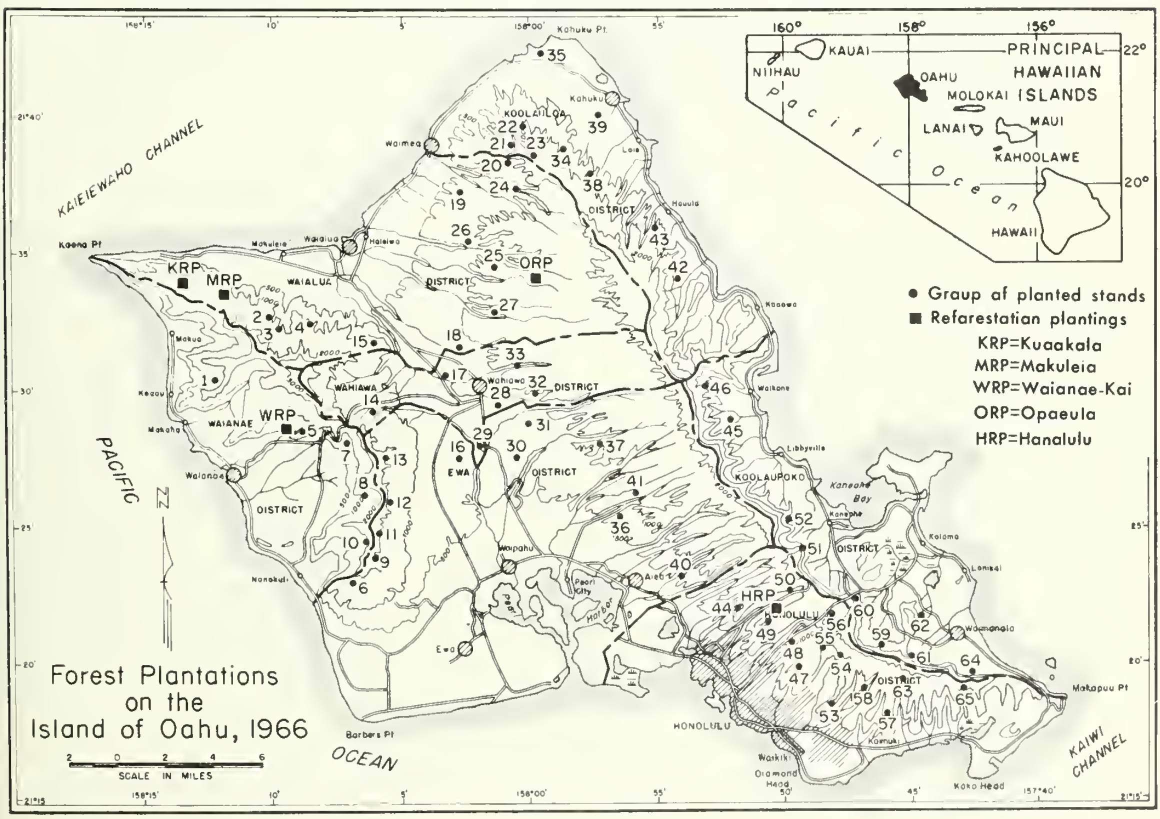
Forest plantations on Oahu total nearly 7,000 acres. They are distributed mainly on the lower slopes around the Waianae and Koolau ranges, above the cultivated and urban areas (see map and tables 12,13). Most of the plantations are concentrated in the Forest Reserves on the easterly slopes of the Waianae range, in the lower reaches of the Kaukonahua watershed, and in the important watershed above Honolulu.

Area

Commercial forest plantations[7] total nearly 4,840 acres in stands from 2 to 171 acres in size (tables 1-4, 12; fig. 3).

Most of the individual plantation stands tallied are of small acreage. Only 15 commercial stands were 50 acres or larger for

[7]See definitions of terms in appendix.



Forest Plantations on the Island of Oahu, 1966

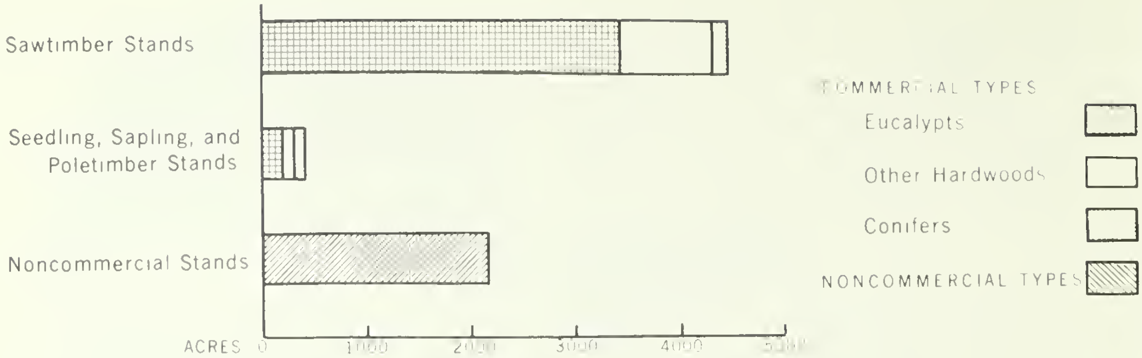


Figure 3.--*Acreage of commercial and noncommercial plantations stands, by stand-size class and forest type, Oahu 1966.*

a total of nearly 1,100 acres. Stands 5 to 49 acres in size aggregate about 2,700 acres. There are 391 stands from 2 to 4 acres in size, totaling some 1,040 acres.

About 4,440 acres of the commercial forest plantations are sawtimber stands. Another 400 acres are recently planted seedling, sapling, and poletimber stands of commercial species.

Of the sawtimber stands, eucalypts--mainly *Eucalyptus robusta* --make up 76 percent, or about 3,400 acres. Other hardwood sawtimber stands total about 900 acres. And there are about 140 acres of commercial conifer sawtimber stands.

Commercial hardwood types account for about 340 acres of the recently planted seedling, sapling and poletimber stands. Another 60 acres are commercial conifer types.

In addition to the commercial forest plantations, there are about 2,140 acres of noncommercial types, mostly paper-bark and ironwood.

Timber Volume

Planted forests on Oahu contain nearly 46 million board feet of sawtimber (tables 5-10). Of this volume about 36 million board feet are in stands 5 acres and larger, and 10 million board feet are in stands of 2 to 4 acres. Most of the sawtimber --39.8 million board feet--is eucalyptus; robusta eucalyptus sawtimber alone amounts to 19.6 million board feet. The volume in hardwoods other than eucalypts totals about 3.5 million board feet. There are 2.5 million board feet of commercial conifer sawtimber, all Norfolk-Island-pine.

In the stands 5 acres and larger, about 37 percent of the sawtimber volume is in trees 19 to 29 inches d.b.h. (table 8). Some 60 percent of the total volume is in trees smaller than 19 inches, and about 3 percent is in trees 29 inches d.b.h. (diameter at breast height) and larger.

In terms of growing stock, the volume in planted sawtimber stands amounts to about 10.9 million cubic feet (tables 7,8). About 78 percent, or some 8.5 million cubic feet of this volume is in eucalypts; robusta eucalyptus alone total some 4.6 million cubic feet. Other hardwoods amount to 1.9 million cubic feet, and conifers, about 0.5 million cubic feet.

There is additional volume of growing stock in the poletimber and sapling and seedling stands, but they were not measured.

Wood in cull trees in planted sawtimber stands 5 acres and larger totals about 640,000 cubic feet (table 9). The 2,140 acres of noncommercial plantations hold an additional, much greater volume of wood in cull trees, but these stands were not measured.

Ownership

Most of the forest plantations on Oahu are privately owned (tables 2, 3, 11). Of the nearly 7,000 acres tallied, including noncommercial types, private owners hold nearly 4,000 acres or 57 percent. The State owns about 1,900 acres or 27 percent. Other publically-owned forest plantations, including military reservations total about 1,100 acres or 16 percent. Most of the plantations are in the Forest Reserves (table 2).

The State owns 45 percent of the sawtimber or about 20.8 million board feet. Private ownership totals 42 percent, or 19.2 million board feet (figs. 4,5). Other public agencies own the balance of about 5.8 million board feet.

Age of Stands

Only about 300 acres of the commercial plantation timber stands are more than 40 years old (table 4). More than 75 percent of the stands (4,320 acres) were planted from 1926 to 1945. Much of this acreage was planted between 1935 and 1941 by the Civilian Conservation Corps. Only 86 acres were planted between 1946 and 1955. Since 1956, less than 135 acres have been planted.

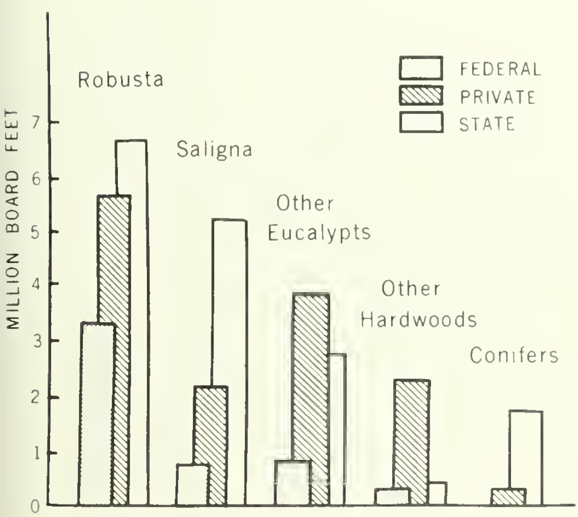


Figure 4.--*Sawtimber volume in planted stands greater than 5 acres in size, by species group and ownership class, Oahu 1966.*

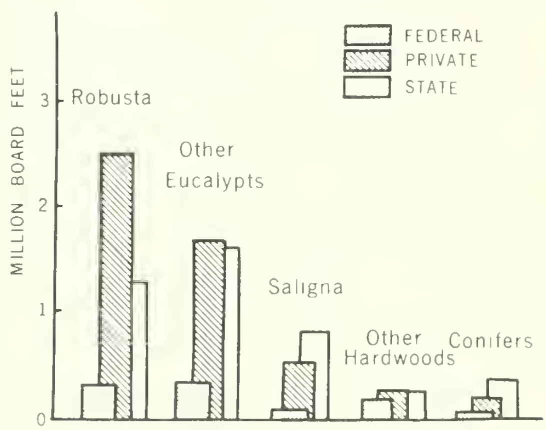


Figure 5.--*Sawtimber volume in planted stands less than 5 acres in size, by species group and ownership class, Oahu 1966.*

Stand Yields

Sawtimber in the planted sawtimber stands averages about 9,400 board feet per acre. But yields differ greatly with stand age, species, site, history and condition of stand, and other factors. The highest stand net volume measured averaged 57,600 board feet per acre in a 40-year-old robusta eucalyptus stand. The next highest yield was in a stand of saligna eucalyptus that averaged 47,700 board feet per acre.

Timber Quality

Saligna eucalyptus sawtimber excells other species in quality, as judged by the proportion of volume in grades 1 and 2 factory lumber logs: 19 percent of it is in grade 1, and 15 percent in grade 2 logs (table 10). Robusta eucalyptus, the hardwood species in greatest volume, has 13 percent of its volume in grade 1 logs and 8 percent in grade 2 logs. Conifer species were not log-graded.

Opportunity for Industrial Development

Planted forests offer much better prospects for industrial development than do native forests. Most of the native or naturalized forests are of particularly poor quality--often just brush. These poorly stocked or nonstocked forests occupying commercial forest lands contain only small amounts of merchantable timber. Only 12,000 of the 90,000 acres of native or naturalized forest types are considered merchantable timber types. And these forests hold only about 6 million board feet of sawtimber.

Harvesting of wood for small amounts of fence posts, fuelwood, and miscellaneous products from native forests will probably continue, but practically none of the native stands offer prospects for sawtimber.

In contrast to the native forests, planted stands have grown rapidly and now yield higher per-acre volumes of timber. In the 4,440 acres of commercial planted forests of sawtimber size, the volume totals about 46 million board feet of sawtimber. Most of the forestation that produced this new timber resource was not done to grow sawtimber, but to control erosion, improve watershed cover, and provide fuelwood. Therefore, species planted were not necessarily selected on the basis of wood quality, but on the basis of adaptability and rapid growth. *Eucalyptus robusta*--a sawtimber species--was highly favored. But so were several species that now offer little or no potential for sawtimber, such as ironwoods (*Casuarina* spp.) and paper-bark (*Melaleuca leucadendron*).

Some of these early plantings demonstrate that timber production potentials are far greater than might be inferred from the data on present total sawtimber volumes on this Island. We know that many valuable introduced timber species are adapted to the different forest sites. An average annual sawtimber growth rate of 1,000 board feet per acre can be expected from managed, well-stocked forests on good sites. And stands can be harvested within 30 to 50 years after establishment.

Although its potential would be limited, a small sawmilling industry could be based on Oahu's present timber resource. It would depend on the development of markets for the small volumes of specialized products for which the timber is useful. And it could operate only on a small scale or for a very few years.

There is, however, a potential to develop a much larger timber resource, which could serve as a base for a significant local milling industry. If only 20 percent of the 97,000 acres of presently little-used and unmanaged commercial forest land were planted to introduced species and managed, timber production could amount to about 15 million board feet annually in 30 years. This production is significant in relation to the present imports of wood amounting to some 100 million feet annually.

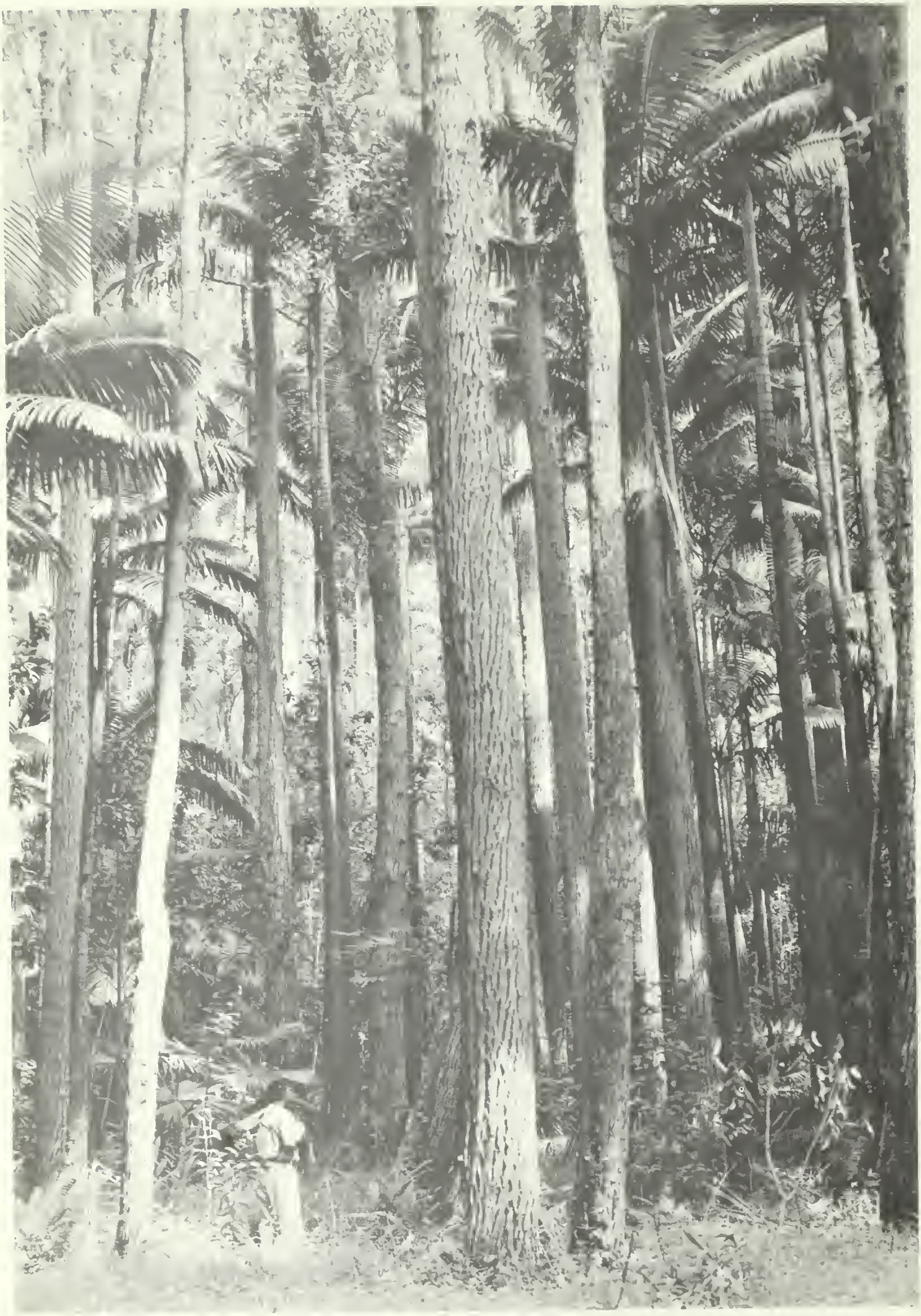
Recent forestation by the State are in part an attempt to capitalize on this potential. In selecting species, foresters are considering wood qualities and adaptability to specific sites. They are planting on nonstocked lands or lands where forests are of particularly poor quality. Reforestation efforts should be greatly expanded to bring a much greater forest area under management. The amount of reforestation accomplished during the next 10 years will determine in large part the amount of timber that might be available 30 to 40 years from now as a base for a local forest products industry.

Multiple Values of Forest

Forests provide many values besides timber. On Oahu their value for watershed protection and for recreation use far exceeds their value for timber. Plantations established primarily for watershed protection and erosion control have greatly improved the landscape and increased opportunities for forest recreation. Planted forests of introduced trees now provide the most attractive and heavily used forest recreation sites on the Island. They also can provide improved wildlife habitat. They can be used to produce Christmas trees in much greater numbers for local use or export. Norfolk-Island-pine grows well and is a readily marketable Christmas tree.

These multiple benefits of planted forests accrue continuously year after year. In addition, periodic harvests of timber can be made without detracting from and often enhancing the recreation and watershed values.

Because vast acreages of mountain lands on Oahu must be maintained in forest cover, both public and private land managers should try to develop all the potential benefits latent in these lands. It has been amply demonstrated on a small scale in the existing plantations that reforestation can enhance recreation use, watershed values, timber production, and wildlife habitat.



Stands of robusta eucalyptus and palm trees in upper Manoa Valley show the typical nature and beauty of a planted forest.

Species of eucalypts are being tested for suitability to Hawaiian sites in this experimental forest established in 1913 in Nuuanu Valley by the Hawaii Division of Forestry.

Monkey-pod trees, one of the lesser species in Hawaii, are a source of valuable craftwood.

Norfolk-Island-pine can be produced in much greater numbers on Oahu's forest lands, for local consumption and for export as Christmas trees.

Planted forests of introduced trees provide an attractive setting for recreation on Oahu.

Appendix

Definitions

Commercial and Noncommercial

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground.

> *Commercial forest land:* Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.
>
> *Noncommercial forest land:* (a) *Productive-reserved* forest land withdrawn from timber use through statute or administrative regulation, and (b) *unproductive* forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of the growing space is occupied by planted trees (introduced species in this report), regardless of native species predominance.

> *Commercial forest plantation:* A plantation of commercial tree species on commercial forest land.
>
> *Noncommercial forest plantation:* A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuelwood or fence posts are excluded. The following were tallied on plots:

Scientific Name	*Common Name*
Acacia koa	koa
Albizia falcata (A. moluccana)	Molucca albizzia
Angophora lanceolata	lanceleaf gum-myrtle
Araucaria excelsa	Norfolk-Island-pine
Cinnamomum camphora	camphor-tree
Eucalyptus calophylla	marri
Eucalyptus citriodora	lemon-gum eucalyptus
Eucalyptus gummifera	bloodwood eucalyptus
Eucalyptus microcorys	tallowwood eucalyptus
Eucalyptus paniculata	gray ironbark eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus resinifera	kinogum eucalyptus

Scientific Name	*Common Name*
Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus sideroxylon	red-ironbark eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Mangifera indica	mango
Metrosideros collina (M. polymorpha)	ohia
Pithecellobium saman	monkey-pod
Syncarpia glomulifera (S. laurifolia)	turpentine-tree
Terminalia myriocarpa	jhalna
Tristania conferta	brushbox

Other frequently planted commercial tree species not tallied in plots:

Scientific Name	*Common Name*
Agathis robusta	Australian kauri
Cryptomeria japonica	sugi
Eucalyptus cornuta	yate
Eucalyptus spp.	unidentified eucalyptus
Swietenia mahagoni	West Indies mahogany
Toona ciliata var. *australis*	Australian toon

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following were tallied on plots:

Scientific Name	*Common Name*
Acacia decurrens	black-wattle acacia
Aleurites moluccana	kukui (candlenut-tree)
Casuarina spp.	ironwoods
Cinnamomum zeylanicum	cinnamon
Cupressus macrocarpa	Monterey cypress
Cupressus spp.	cypress
Diospyros sandwicensis	lama
Erythrina sandwicensis	wiliwili
Eucalyptus globulus	bluegum eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Eugenia cumini	Java-plum
Melaleuca leudadendron	paper-bark
Melia azedarach	pride-of-India
Melochia indica	melochia
Pisonia inermis	papala-kepau
Pithecellobium dulce	opiuma

Scientific Name	*Common Name*
Pritchardia spp.	loulu palm
Santalum spp.	sandalwood
Straussia spp.	kopiko

Other oft-planted noncommercial tree species not tallied on plots:

Scientific Name	*Common Name*
Acacia confusa	Formosa koa
Ficus sp.	fig
Haematoxylon campechianum	logwood
Jacaranda mimosifolia	jacaranda
Platymiscium stipulare	roble

Hardwoods: Dicotyledonous trees; usually broadleaved.

Conifers: Coniferous trees; usually evergreen, having needle or scale-like leaves. Also generally known as softwoods.

Forest types or species type: Forests which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type, ohia type, or tropical ash type. Otherwise they are designated:

Mixed eucalyptus type: Planted stands predominantly of eucalyptus species.

Mixed hardwood type: Planted stands predominantly of hardwoods other than the eucalypts.

Mixed conifer type: Planted forests predominantly of conifers.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

Sawtimber trees: Live trees of commercial species of at least 11.0 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.

Poletimber trees: Live trees of commercial species between 5.0 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.

Saplings and seedlings: Live trees of commercial species between 1.0 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Sawtimber: Wood in trees defined as sawtimber trees.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections, V equals 0.905 $(0.22D^2 - 0.71D)$.

Sawtimber volume: The net volume of the saw-log portion of sawtimber trees, in board feet, International 1/4-inch rule.

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable sawlog cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5.0 inches d.b.h. or larger, from stump to a minimum top diameter inside bark (d.i.b.) of 4.0 inches.

Stand-Size Classes

Sawtimber stands: Stands at least 10 percent stocked with growing stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing-stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing-stock trees.

Nonstocked: Commercial forest lands less than 10 percent stocked with growing-stock trees.

Miscellaneous

Diameter breast height (d.b.h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as sawlogs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value of lumber the logs will yield. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[8] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, these are usually inherent in a species.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand-by-plantation stand. First, individual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured from the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and

---

[8] U.S. Forest Products Laboratory. *Hardwood log grades for standard lumber--proposals and results.* U.S. Forest Serv. Forest Prod. Lab. Rep. 1737, 15 pp., illus. 1953.

variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared computer program. Tree measurements were converted to meaningful volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreage of the stand. The computer output consisted of tabular data for each stand and summaries of stand data by forest reserves.

Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands.

The accuracy goal for this inventory was ± 20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. The reliability of estimates for each forest reserve, based on measured stands only, are shown below. Two chances out of three the estimated volume does not vary from the actual by greater than the sampling error indicated.

	Total volume (thousand bd. ft.)	Sampling error (percent)
Forest Reserve:		
Ewa	12,641	7.8
Hauula	185	23.2
Honolulu	4,301	7.6
Honouliuli	6,270	10.1
Kahuku	350	11.9
Kaneohe	164	35.9
Kawailoa	326	23.2
Mokuleia	403	7.4
Nanakuli	149	38.7
Pupukea	1,194	47.4
Waiahole	967	33.1
Waianae-kai	1,032	36.0
Waimanalo	149	12.0
Outside Forest Reserve	7,489	10.4

Table 1.--Area of forest plantations for all ownerships by forest type and forest reserve, Island of Oahu, 1966

Forest reserve	Commercial forest types			Total commercial types	Total noncommercial types	Total all types
	Eucalypts[1/]	Other hardwoods	Conifers[2/]			
	Acres					
Ewa	892	9	3	904	265	1,169
Hauula	13	--	28	41	34	75
Honolulu	325	65	32	422	412	834
Honouliuli	758	819	4	1,581	142	1,723
Kahuku	21	--	31	52	173	225
Kaneohe	15	--	--	15	8	23
Kawailoa	71	16	10	97	38	135
Kuliouou	--	--	--	--	4	4
Makua-Keaau	3	21	--	24	--	24
Mokuleia	55	9	46	110	--	110
Nanakuli	14	38	--	52	2	54
Pupukea	121	--	--	121	93	214
Schofield Barracks	3	10	--	13	75	88
Waiahole	34	7	35	76	8	84
Waianae-Kai	85	--	--	85	23	108
Waimanalo	95	7	--	102	13	115
Outside Reserve	1,110	24	6	1,140	849	1,989
Total	3,615	1,025	195	4,835	2,139	6,974

1/ Includes turpentine-tree, brushbox, lanceleaf gum-myrtle.
2/ Mainly Norfolk-Island-pine but includes some sugi and Australian kauri.

Table 2.--Area of forest plantations by ownership class,[1] forest type, and forest reserve, Island of Oahu, 1966

Ownership and forest reserve	Commercial forest type			Total commercial types	Total non-commercial types	Total all types
	Eucalypts[2]	Other hardwoods	Conifers			
	Acres					
State:						
Ewa	479	9	--	488	30	518
Hauula	6	--	28	34	34	68
Honolulu	249	51	32	332	211	543
Kaneohe	12	--	--	12	--	12
Kuliouou	--	--	--	--	4	4
Makua-Keaau	3	21	--	24	--	24
Mokuleia	55	9	46	110	--	110
Nanakuli	14	38	--	52	2	54
Pupukea	118	--	--	118	93	211
Waiahole	32	--	35	67	8	75
Waianae-Kai	85	--	--	85	23	108
Waimanalo	69	7	--	76	2	78
Outside Reserve	49	--	--	49	27	76
Total	1,171	135	141	1,447	434	1,881
Other Public:						
Ewa	189	--	--	189	84	273
Honolulu	53	12	--	65	201	266
Schofield Barracks	3	10	--	13	75	88
Outside Reserve	405	18	4	427	85	512
Total	650	40	4	694	445	1,139
Private:						
Ewa	224	--	3	227	151	378
Hauula	7	--	--	7	--	7
Honolulu	23	2	--	25	--	25
Honouliuli	758	819	4	1,581	142	1,723
Kahuku	21	--	31	52	173	225
Kaneohe	3	--	--	3	8	11
Kawailoa	71	16	10	97	38	135
Pupukea	3	--	--	3	--	3
Waiahole	2	7	--	9	--	9
Waimanalo	26	--	--	26	11	37
Outside Reserve	656	6	2	664	737	1,401
Total	1,794	850	50	2,694	1,260	3,954
Island total	3,615	1,025	195	4,835	2,139	6,974

[1] Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand, the ownership designation may be in error, although over-all ownership statistics are probably not greatly affected by this kind of error.

[2] Includes turpentine-tree, brushbox, and lanceleaf gum-myrtle.

Table 3.--Area of forest plantations by forest type, ownership class, and stand-size class, Island of Oahu, 1966

Stand-size class and forest type	Ownership class: State	Ownership class: Other public	Ownership class: Private	All ownerships
	Acres			
Commercial types:				
Sawtimber stands				
Robusta eucalyptus	388	329	880	1,597
Saligna eucalyptus	166	18	102	286
Blackbutt eucalyptus	60	4	119	183
Gray ironbark eucalyptus	46	--	49	95
Other eucalypts[1]	256	186	490	932
Brushbox	160	58	99	317
Silk-oak	46	4	750	800
Other hardwoods	48	30	14	92
Conifers	95	4	40	139
Total	1,265	633	2,543	4,441
Poletimber stands				
Robusta eucalyptus	--	51	9	60
Gray ironbark eucalyptus	23	--	16	39
Other eucalypts[1]	6	--	10	16
Brushbox	21	4	15	40
Silk-oak	24	--	67	91
Other hardwoods	2	6	3	11
Total	76	61	120	257
Seedling and sapling stands				
Robusta eucalyptus	--	--	3	3
Saligna eucalyptus	42	--	--	42
Other eucalypts[1]	--	--	2	2
Brushbox	3	--	--	3
Other hardwoods	15	--	16	31
Conifers	46	--	10	56
Total	106	--	31	137
Total commercial	1,447	694	2,694	4,835
Noncommercial types:				
Eucalyptus spp.	14	--	51	65
Ironwood	164	261	798	1,223
Paper-bark	232	174	406	812
Other hardwoods	24	10	--	34
Conifers	--	--	5	5
Total noncommercial	434	445	1,260	2,139
Total forest plantation	1,881	1,139	3,954	6,974

1/ Includes turpentine-tree and lanceleaf gum-myrtle.

Table 4.--Area of forest plantations by forest type and period planted, Island of Oahu, 1966

Forest type	Period of planting							Total
	1896-1905	1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1966	
	Acres							
Commercial types:								
Robusta eucalyptus	--	8	128	896	574	51	3	1,660
Saligna eucalyptus	--	--	23	34	229	--	42	328
Blackbutt eucalyptus	--	--	--	76	107	--	--	183
Gray ironbark eucalyptus	--	4	--	33	97	--	--	134
Other eucalypts 1/	--	26	95	376	440	7	2	946
Brushbox	--	--	--	69	280	15	--	364
Silk-oak	--	--	--	25	864	2	--	891
Other hardwoods	7	--	8	39	38	11	50	153
Conifers	--	--	4	84	51	--	37	176
Total commercial	7	38	258	1,632	2,680	86	134	4,835
Noncommercial types:								
Ironwood	--	--	83	496	644	--	--	1,223
Paper-bark	--	--	--	198	614	--	--	812
Other hardwoods	--	--	--	9	25	--	--	34
Monterey cypress	--	--	--	5	--	--	--	5
Unidentified eucalypts	--	--	14	43	8	--	--	65
Total noncommercial	--	--	97	751	1,291	--	--	2,139
Total	7	38	355	2,383	3,971	86	134	6,974

1/ Includes turpentine-tree and lanceleaf gum-myrtle.

Table 5.--Volume of growing stock and sawtimber in planted sawtimber stands by stand-size class and species, Island of Oahu, 1966

Species	Stands 2 to 4 acres in size		Stands 5 acres and larger		All stands	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu. ft.	Bd.ft.[1]	Cu. ft.	Bd.ft.[1]	Cu. ft.	Bd.ft.[1]
	(in thousands of feet)					
Blackbutt eucalyptus	397	1,825	504	2,456	901	4,281
Bloodwood eucalyptus	--	--	5	27	5	27
Brushbox	212	526	378	1,109	590	1,635
Gray ironbark eucalyptus	98	266	262	792	360	1,058
Jhalna	--	--	13	29	13	29
Kinogum eucalyptus	--	--	3	8	3	8
Koa	--	--	13	59	13	59
Lanceleaf gum-myrtle	--	--	6	26	6	26
Lemon-gum eucalyptus	--	--	258	1,179	258	1,179
Marri eucalyptus	--	--	70	367	70	367
Molucca albizzia	--	--	64	272	64	272
Monkey-pod	--	--	22	120	22	120
Norfolk-Island-pine[2]	118	516	425	1,986	543	2,502
Ohia	--	--	1	3	1	3
Other hardwoods[3]	124	459	--	--	124	459
Red-ironbark eucalyptus	--	--	7	26	7	26
Robusta eucalyptus	900	4,076	3,650	15,483	4,550	19,559
Saligna eucalyptus	265	1,368	1,484	7,991	1,749	9,359
Silk-oak	77	180	976	2,356	1,053	2,536
Tallowwood eucalyptus	--	--	22	101	22	101
Tropical ash	--	--	13	23	13	23
Turpentine-tree	--	--	67	235	67	235
Unidentified eucalypts	248	990	236	972	484	1,962
Total	2,439	10,206	8,479	35,620	10,918	45,826

1/ International 1/4-inch rule.

2/ Mainly Norfolk-Island-pine, but includes sugi and Australian kauri.

3/ Australian toon, camphor-tree, mango, West Indies mahogany.

Table 6.--Volume of growing stock and sawtimber in planted sawtimber stands 5 acres and larger, by ownership class1/ and species, Island of Oahu, 1966

Species	State		Other public		Private		Total	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/
	(in thousands of feet)							
Robusta eucalyptus	1,424	6,614	757	3,242	1,469	5,627	3,650	15,483
Saligna eucalyptus	938	5,166	133	722	413	2,103	1,484	7,991
Blackbutt eucalyptus	139	739	13	51	352	1,666	504	2,456
Gray ironbark eucalyptus	56	198	59	206	147	388	262	792
Other eucalypts3/	235	1,106	108	394	330	1,440	673	2,940
Brushbox	241	674	34	82	103	353	378	1,109
Silk-oak	40	131	--	--	936	2,225	976	2,356
Other hardwoods4/	62	235	59	256	6	16	127	507
Norfolk-Island-pine	360	1,694	--	--	65	292	425	1,986
Total	3,495	16,557	1,163	4,953	3,821	14,110	8,479	35,620

1/ See footnote 1, table 2.
2/ International 1/4-inch rule.
3/ Mainly *Eucalyptus* spp. but includes turpentine-tree.
4/ Jhalna, koa, lanceleaf gum-myrtle, Molucca albizzia, monkey-pod, ohia, and tropical ash.

Table 7.--Volume of growing stock and sawtimber in planted sawtimber stands 2 to 4 acres in size, by ownership class1/ and species, Island of Oahu, 1966

Species	State		Other public		Private		Total	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/	Cu. ft.	Bd.ft.2/
	(in thousands of feet)							
Robusta eucalyptus	270	1,250	68	297	562	2,529	900	4,076
Saligna eucalyptus	154	821	9	38	102	509	265	1,368
Blackbutt eucalyptus	152	737	20	101	225	987	397	1,825
Gray ironbark eucalyptus	48	151	17	37	33	78	98	266
Other eucalypts3/	127	527	27	108	94	355	248	990
Brushbox	86	217	37	63	89	246	212	526
Silk-oak	7	13	5	8	65	159	77	180
Other hardwoods4/	61	223	40	157	23	79	124	459
Conifers5/	64	328	6	7	48	181	118	516
Total	969	4,267	229	816	1,241	5,123	2,439	10,206

1/ See footnote 1, table 2.
2/ International 1/4-inch rule.
3/ Mainly *Eucalyptus* spp. but includes turpentine-tree.
4/ Australian toon, jhalna, koa, lanceleaf gum-myrtle, mango, Molucca albizzia, monkey-pod, ohia, tropical ash, and West Indies mahogany.
5/ Mainly Norfolk-Island-pine, but includes some sugi and Australian kauri.

Table 8.--Volume of sawtimber and growing stock in planted sawtimber stands 5 acres and larger by species and diameter class, Island of Oahu, 1966

Species	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
				Sawtimber in thousand board feet[1]					
Robusta eucalyptus	15,483	--	1,362	2,044	2,809	2,464	6,263	521	20
Saligna eucalyptus	7,991	--	214	760	1,262	1,512	4,121	113	9
Blackbutt eucalyptus	2,456	--	83	235	352	486	1,230	70	--
Gray ironbark eucalyptus	792	--	193	245	168	123	63	--	--
Other eucalypts[2]	2,940	--	225	363	350	564	1,188	166	84
Brushbox	1,109	--	296	401	236	130	46	--	--
Silk-oak	2,356	--	998	702	361	227	59	9	--
Other hardwoods[3]	507	--	55	90	57	96	141	65	3
Norfolk-Island-pine	1,986	--	159	387	574	626	240	--	--
Total	35,620	--	3,585	5,227	6,169	6,228	13,351	944	116
				Growing stock in thousand cubic feet					
Robusta eucalyptus	3,560	385	532	514	566	461	1,103	86	3
Saligna eucalyptus	1,484	46	81	182	239	260	657	18	.1
Blackbutt eucalyptus	504	9	32	62	74	94	221	12	--
Gray ironbark eucalyptus	262	87	61	52	30	21	11	--	--
Other eucalypts[2]	673	74	84	91	71	107	203	29	14
Brushbox	378	124	91	85	46	23	9	--	--
Silk-oak	976	413	290	150	70	40	12	1	--
Other hardwoods[3]	127	23	17	21	12	18	25	11	--
Norfolk-Island-pine	425	44	51	79	103	108	40	--	--
Total	8,479	1,205	1,239	1,236	1,211	1,132	2,281	157	18

1/ International 1/4-inch rule.
2/ Mainly *Eucalyptus* spp. but includes turpentine-tree.
3/ Jhalna, koa, lanceleaf gum-myrtle, Molucca albizzia, monkey-pod, ohia, and tropical ash.

Table 9.--Volume of cull trees in planted sawtimber stands, 5 acres and larger, by forest reserve and species, Island of Oahu, 1966

Forest reserve	Species									Total all species
	Robusta eucalyptus	Saligna eucalyptus	Blackbutt eucalyptus	Other eucalypts 1/	Brush-box	Silk-oak	Other hard-woods 2/	Norfolk-Island-pine	Noncom-mercial species 3/	
	Thousand cubic feet									
Ewa	59	8	4	12	4	--	8	--	24	119
Hauula	--	--	--	--	--	--	--	1	2	3
Honolulu	8	--	--	5	--	--	3	1	50	67
Honouliuli	49	2	1	14	2	83	6	--	140	297
Kahuku	--	--	--	--	1	--	--	--	--	1
Kaneohe	2	--	--	--	2	--	--	--	--	4
Kawailoa	--	--	3	--	--	--	--	--	--	3
Kuliouou	--	--	--	--	--	--	--	--	--	--
Makua-Keeau	--	--	--	--	--	--	--	--	--	--
Mokuleia	--	1	--	--	--	--	--	--	--	1
Nanakuli	--	--	--	--	--	2	--	--	2	4
Pupukea	7	--	--	--	2	1	2	--	16	28
Schofield Barracks	--	--	--	--	--	--	--	--	--	--
Waiahole	--	--	--	--	--	--	--	2	--	2
Waianae-Kai	5	--	--	5	--	--	--	--	5	15
Waimanalo	1	--	--	--	--	--	--	--	2	3
Outside Reserve	75	1	--	3	4	--	1	--	14	98
Total	206	12	8	39	15	86	20	4	255	645

1/ Mainly *Eucalyptus* spp. but includes turpentine-tree.

2/ Includes Australian toon, jhalna, koa, lanceleaf gum-myrtle, mango, monkey-pod, ohia, tropical ash, and West Indies mahogany.

3/ Includes black-wattle acacia, bluegum eucalyptus, cinnamon, cypress, ironwoods, Java-plum, kopiko, kukui, lama, loulu, melochia, opiuma, papala-kepau, paper-bark, pride-of-India, unidentified eucalypts, sandalwood, and wiliwili.

Table 10.--Sawtimber volume in planted sawtimber stands 5 acres and larger by ownership class, species, and log grade[1/] Island of Oahu, 1966

Ownership class and species	All grades	Factory lumber logs Grade 1	Grade 2	Grade 3	Tie and timber logs Grade 4	Softwood species[2/]
	------------------	Thousand board feet[3/]	------------------			
State:						
Robusta eucalyptus	6,614	896	479	1,281	3,958	--
Saligna eucalyptus	5,166	1,205	670	1,093	2,198	--
Blackbutt eucalyptus	739	110	121	195	313	--
Gray ironbark eucalyptus	198	14	25	61	98	--
Other eucalypts[4/]	1,106	229	119	265	493	--
Brushbox	674	--	--	129	545	--
Silk-oak	131	2	12	41	76	--
Other hardwoods[5/]	235	52	31	38	114	--
Norfolk-Island-pine	1,694	--	--	--	--	1,694
Total	16,557	2,508	1,457	3,103	7,795	1,694
Other public:						
Robusta eucalyptus	3,242	330	269	516	2,127	--
Saligna eucalyptus	722	99	119	205	299	--
Blackbutt eucalyptus	51	--	2	9	40	--
Gray ironbark eucalyptus	206	--	18	38	150	--
Other eucalypts[4/]	394	31	17	66	280	--
Brushbox	82	--	--	--	82	--
Other hardwoods[5/]	256	21	45	34	156	--
Total	4,953	481	470	868	3,134	--
Private:						
Robusta eucalyptus	5,627	825	440	838	3,524	--
Saligna eucalyptus	2,103	230	383	483	1,007	--
Blackbutt eucalyptus	1,666	116	147	386	1,017	--
Gray ironbark eucalyptus	388	17	15	93	263	--
Other eucalypts[4/]	1,440	348	156	289	647	--
Brushbox	353	20	15	110	208	--
Silk-oak	2,225	--	21	301	1,903	--
Other hardwoods[5/]	16	--	--	7	9	--
Norfolk-Island-pine	292	--	--	--	--	292
Total	14,110	1,556	1,177	2,507	8,578	292
All ownerships:						
Robusta eucalyptus	15,483	2,051	1,188	2,635	9,609	--
Saligna eucalyptus	7,991	1,534	1,172	1,781	3,504	--
Blackbutt eucalyptus	2,456	226	270	590	1,370	--
Gray ironbark eucalyptus	792	31	58	192	511	--
Other eucalypts[4/]	2,940	608	292	620	1,420	--
Brushbox	1,109	20	15	239	835	--
Silk-oak	2,356	2	33	342	1,979	--
Other hardwoods[5/]	507	73	76	79	279	--
Norfolk-Island-pine	1,986	--	--	--	--	1,986
Total	35,620	4,545	3,104	6,478	19,507	1,986

1/ Based on standard specifications for hardwood log grades for standard lumber.
2/ Commercial conifer species were not log graded.
3/ International 1/4-inch rule.
4/ Mainly *Eucalyptus* spp. but includes turpentine-tree.
5/ Jhalna, koa, lanceleaf gum-myrtle, Molucca albizzia, monkey-pod, ohia, and tropical ash.

Table 11.--Listing of individual stands and plantings with species type, ownership, area, and volume Island of Oahu, 1966

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
[1]3001				
3002	Gray ironbark eucalyptus	State	2	3
3003	Mixed eucalypts	Private	34	641
3004	Silk-oak	Private	8	49
3005	Ironwood	State	11	([2])
3006	Mixed eucalypts	State	24	232
3007	Mixed eucalypts	State	34	447
3008	Bluegum eucalyptus	State	2	([2])
3009	Kinogum eucalyptus	State	3	25
3010	Lemon-gum eucalyptus	State	5	67
3011	Robusta eucalyptus	State	2	5
3012	Saligna eucalyptus	State	20	403
3013	Saligna eucalyptus	State	3	60
3014	Mixed eucalypts	State	2	40
3015	Mixed eucalypts	State	2	40
3016	Mixed eucalypts	State	4	6
3017	Robusta eucalyptus	Private	3	1
3018	Paper-bark	Private	9	([2])
3019	Gray ironbark eucalyptus	Private	2	([3])
3020	Gray ironbark eucalyptus	Private	18	28
3021	Mixed eucalypts	Private	22	25
3022	Gray ironbark eucalyptus	Private	8	([3])
3023	Bluegum eucalyptus	Private	8	([2])
3024	Gray ironbark eucalyptus	Private	4	6
3025	Silk-oak	Private	2	([3])
3026	Lemon-gum eucalyptus	Private	7	58
3027	Mixed eucalypts	Private	79	61
3028	Robusta eucalyptus	Private	80	200
3029	Mixed eucalypts	Other public	36	67
3030	Norfolk-Island-pine	Other public	2	3

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3031	Norfolk-Island-pine	Other public	2	3
3032	Robusta eucalyptus	Other public	3	52
3033	Paper-bark	Private	7	(2/)
3034	Paper-bark	Private	2	(2/)
3035	Eucalyptus spp.	Private	3	24
3036	Silk-oak	Private	36	(3/)
3037	Robusta eucalyptus	Private	2	16
3038	Roble	State	2	(2/)
3039	Brushbox	State	3	20
3040	Eucalyptus spp.	Private	3	10
3041	Robusta eucalyptus	Private	4	32
3042	Silk-oak	Private	3	18
3043	Brushbox	Private	2	3
3044	Silk-oak	Private	2	11
3045	Eucalyptus spp.	Private	3	6
3046	Saligna eucalyptus	Private	3	14
3047	Mixed eucalypts	Private	68	149
3048	Robusta eucalyptus	Private	26	100
3049	Robusta eucalyptus	Private	63	511
3050	Mixed eucalypts	Private	14	13
3051	Robusta eucalyptus	State	2	17
3052	Eucalyptus spp.	Private	4	37
3053	Silk-oak	Private	5	19
3054	Silk-oak	Private	50	169
3055	Silk-oak	Private	17	52
3056	Lemon-gum eucalyptus	Private	4	(3/)
3057	Lemon-gum eucalyptus	Private	2	7
3058	Silk-oak	Private	5	12
3059	Lemon-gum eucalyptus	Private	19	64
3060	Silk-oak	Private	18	39

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3061	Silk-oak	Private	4	22
3062	Bluegum eucalyptus	State	2	(2/)
3063	Mixed eucalypts	Private	8	16
3064	Mixed eucalypts	Private	4	58
3065	Silk-oak	Private	7	121
3066	Silk-oak	Private	32	176
3067	Ironwood	Private	30	(2/)
3068	Robusta eucalyptus	State	2	2
3069	Robusta eucalyptus	Private	4	32
3070	Mixed eucalypts	State	2	26
3071	Robusta eucalyptus	Private	22	185
3072	Silk-oak	Private	4	16
3073	Silk-oak	Private	2	3
3074	Silk-oak	Private	4	14
3075	Paper-bark	State	26	(2/)
3076	Ironwood	Private	5	(2/)
3077	Silk-oak	Private	19	10
3078	Silk-oak	Private	171	257
3079	Robusta eucalyptus	Private	4	15
3080	Paper-bark	Private	5	(2/)
3081	Paper-bark	Private	4	(2/)
3082	Sugi	Private	4	17
3083	Gray ironbark eucalyptus	State	11	90
3084	Silk-oak	State	11	21
3085	Silk-oak	State	16	32
3086	Silk-oak	State	8	6
3087	Silk-oak	State	3	2
3088	Tropical ash	Private	5	4
3089	Saligna eucalyptus	Private	2	9
3090	Mixed eucalypts	Private	4	18

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3091	Robusta eucalyptus	Private	3	14
3092	Silk-oak	Private	5	12
3093	Silk-oak	Private	6	3
3094	Mixed eucalypts	Private	10	46
3095	Tropical ash	Private	3	(3/)
3096	Silk-oak	Private	16	14
3097	Robusta eucalyptus	Private	4	18
3098	Turpentine-tree	Private	4	37
3099	Gray ironbark eucalyptus	Private	5	30
3100	Turpentine-tree	Private	17	159
3101	Silk-oak	Private	40	62
3102	Silk-oak	Private	11	41
3103	Silk-oak	Private	15	1
3104	Silk-oak	Private	53	81
3105	Paper-bark	Private	22	(2/)
3106	Brushbox	Private	7	47
3107	Silk-oak	Private	10	105
3108	Silk-oak	Private	2	3
3109	Robusta eucalyptus	Private	14	204
3110	Mixed eucalypts	Private	8	129
3111	Blackbutt eucalyptus	Private	8	126
3112	Brushbox	Private	13	207
3113	Brushbox	Private	2	(3/)
3114	Silk-oak	Private	6	9
3115	Robusta eucalyptus	Private	3	44
3116	Silk-oak	Private	22	15
3117	Robusta eucalyptus	State	6	286
3118	Silk-oak	Private	30	336
3119	Blackbutt eucalyptus	Private	18	218
3120	Silk-oak	Private	85	405

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3121	Silk-oak	Private	60	125
3122	Robusta eucalyptus	State	27	492
3123	Robusta eucalyptus	Private	31	273
3124	Silk-oak	Private	4	(3/)
3125	Silk-oak	Private	9	(3/)
3126	Silk-oak	Private	3	6
3127	Robusta eucalyptus	Private	16	84
3128	Robusta eucalyptus	Private	17	84
3129	Saligna eucalyptus	Private	4	18
3130	Paper-bark	Private	44	(2/)
3131	Brushbox	Private	4	64
1/ 3132				
3133	Mixed eucalypts	Private	19	371
3134	Mixed eucalypts	Other public 4/	19	157
3135	Saligna eucalyptus	Private	4	111
3136	Saligna eucalyptus	Private	4	111
3137	Silk-oak	Private	2	4
3138	Paper-bark	Other public	5	(2/)
3139	Silk-oak	Other public	4	8
3140	Brushbox	Other public	19	58
3141	Tropical ash	Other public	6	(3/)
3142	Brushbox	Other public	3	9
3143	Molucca albizzia	Other public	3	47
3144	Paper-bark	Other public	40	(2/)
3145	Ironwood	Other public	30	(2/)
3146	Robusta eucalyptus	Other public	20	112
3147	Mixed eucalypts	Other public	4	33
3148	Mixed eucalypts	Other public	4	33
3149	Robusta eucalyptus	Other public	3	17
3150	Brushbox	Other public	2	6

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3151	Robusta eucalyptus	Other public	3	21
3152	Molucca albizzia	Other public	15	234
3153	Robusta eucalyptus	Other public	12	60
3154	Robusta eucalyptus	Other public	38	145
3155	Robusta eucalyptus	Other public	6	59
3156	Robusta eucalyptus	Other public	6	43
3157	Robusta eucalyptus	Other public	7	49
3158	Lemon-gum eucalyptus	Private	3	40
3159	Silk-oak	Private	2	4
3160	Mixed eucalypts	Private	13	6
3161	Mixed eucalypts	Private	4	14
3162	Bluegum eucalyptus	Private	10	(2/)
3163	Mixed eucalypts	Other public	4	26
3164	Mixed eucalypts	Other public	3	20
3165	Mixed eucalypts	Other public	28	184
3166	Eucalyptus spp.	Other public	6	8
3167	Robusta eucalyptus	Other public	16	57
3168	Robusta eucalyptus	Private	3	112
3169	Robusta eucalyptus	Private	25	932
3170	Robusta eucalyptus	Private	10	289
3171	Robusta eucalyptus	Private	8	42
1/ 3172				
3173	Robusta eucalyptus	Private	57	300
3174	Robusta eucalyptus	Private	10	78
3175	Robusta eucalyptus	State	16	302
3176	Ironwood	Private	10	(2/)
3177	Ironwood	Private	6	(2/)
3178	Mixed eucalypts	Private	2	16
3179	Ironwood	Private	5	(2/)
3180	Ironwood	Private	4	(2/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3181	Ironwood	Private	26	(2/)
3182	Blackbutt eucalyptus	State	4	81
3183	Brushbox	State	4	10
3184	Robusta eucalyptus	Private	4	66
3185	Robusta eucalyptus	Private	4	66
3186	Robusta eucalyptus	State	2	33
3187	Brushbox	State	2	5
3188	Brushbox	State	4	10
3189	Paper-bark	State	2	(2/)
3190	Ironwood	Private	124	(2/)
3191	Paper-bark	State	45	(2/)
3192	Gray ironbark eucalyptus	Private	4	11
3193	Robusta eucalyptus	Private	3	8
3194	Robusta eucalyptus	Private	58	160
3195	Silk-oak	Private	4	8
3196	Robusta eucalyptus	Private	2	2
3197	Robusta eucalyptus	Private	3	2
3198	Robusta eucalyptus	Private	22	17
3199	Saligna eucalyptus	Private	14	83
3200	Mixed eucalypts	Other public	5	30
3201	Robusta eucalyptus	Other public	17	127
3202	Robusta eucalyptus	Other public	77	703
3203	Robusta eucalyptus	Other public	9	65
3204	Robusta eucalyptus	Other public	33	736
3205	Mixed eucalypts	Other public	14	200
3206	Robusta eucalyptus	Other public	3	27
3207	Bluegum eucalyptus	Private	7	(2/)
3208	Bluegum eucalyptus	Private	3	(2/)
3209	Robusta eucalyptus	Private	2	18
3210	Monterey cypress	Private	5	(2/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3211	Robusta eucalyptus	Private	3	49
3212	Bluegum eucalyptus	Private	3	(2/)
3213	Bluegum eucalyptus	Private	12	(2/)
3214	Mixed eucalypts	Private	13	191
3215	Robusta eucalyptus	Private	4	66
3216	Silk-oak	Private	4	42
3217	Ironwood	Private	7	(2/)
3218	Paper-bark	Private	3	(2/)
3219	Silk-oak	Private	3	5
3220	Brushbox	Private	4	12
3221	Brushbox	Private	4	12
3222	Brushbox	Private	3	7
3223	Blackbutt eucalyptus	Private	3	36
3224	Brushbox	Private	3	7
3225	Blackbutt eucalyptus	Private	4	48
3226	Paper-bark	Private	2	(2/)
3227	Blackbutt eucalyptus	Private	3	47
3228	Mixed eucalypts	State	29	603
3229	Mixed eucalypts	Private	16	326
3230	Brushbox	Private	3	48
3231	Gray ironbark eucalyptus	Private	3	6
3232	Paper-bark	Private	6	(2/)
3233	Paper-bark	Private	3	(2/)
3234	Paper-bark	Private	2	(2/)
3235	Paper-bark	Private	3	(2/)
3236	Gray ironbark eucalyptus	Private	4	7
3237	Mixed eucalypts	Private	2	7
3238	Saligna eucalyptus	Private	2	66
3239	Paper-bark	Private	7	(2/)
3240	Robusta eucalyptus	State	17	321

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3241	Robusta eucalyptus	Private	3	49
3242	Ironwood	Private	64	(2/)
3243	Robusta eucalyptus	Private	4	66
3244	Robusta eucalyptus	State	12	228
3245	Robusta eucalyptus	Private	2	38
3246	Robusta eucalyptus	State	33	543
3247	Ironwood	State	17	(2/)
3248	Brushbox	State	4	10
3249	Robusta eucalyptus	State	8	168
3250	Paper-bark	State	4	(2/)
3251	Blackbutt eucalyptus	State	2	41
3252	Brushbox	Private	2	5
3253	Blackbutt eucalyptus	Private	2	41
3254	Brushbox	Private	3	7
3255	Blackbutt eucalyptus	Private	2	41
3256	Paper-bark	State	3	(2/)
3257	Paper-bark	State	2	(2/)
3258	Paper-bark	State	2	(2/)
3259	Brushbox	Private	3	7
3260	Blackbutt eucalyptus	Private	8	45
3261	Silk-oak	Private	13	79
3262	Saligna eucalyptus	Private	11	363
3263	Tallowwood eucalyptus	State	4	65
3264	Robusta eucalyptus	State	11	178
3265	Brushbox	State	11	61
3266	Molucca albizzia	State	6	7
3267	Robusta eucalyptus	Private	2	6
3268	Robusta eucalyptus	Private	8	20
3269	Robusta eucalyptus	Private	4	10
3270	Ironwood	Private	7	(2/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3271	Robusta eucalyptus	Private	4	12
3272	Robusta eucalyptus	Private	32	93
3273	Ironwood	Private	20	(2/)
3274	Ironwood	Private	2	(2/)
3275	Robusta eucalyptus	Private	4	75
3276	Robusta eucalyptus	Private	4	75
3277	Robusta eucalyptus	Private	4	75
3278	Robusta eucalyptus	Private	12	225
3279	Robusta eucalyptus	Private	3	9
3280	Blackbutt eucalyptus	State	12	182
3281	Paper-bark	State	4	(2/)
3282	Brushbox	State	30	74
3283	Paper-bark	State	9	(2/)
3284	Blackbutt eucalyptus	Private	6	56
3285	Blackbutt eucalyptus	Private	4	61
3286	Robusta eucalyptus	Private	2	33
3287	Gray ironbark eucalyptus	Private	2	33
3288	Paper-bark	Private	2	(2/)
3289	Paper-bark	Private	63	(2/)
3290	Ironwood	Private	5	(2/)
3291	Ironwood	Private	103	(2/)
3292	Robusta eucalyptus	Private	3	52
3293	Eucalyptus spp.	Private	4	14
3294	Silk-oak	Private	5	(3/)
3295	Silk-oak	Private	3	2
3296	Silk-oak	Private	5	(3/)
3297	Lemon-gum eucalyptus	Private	2	56
3298	Lemon-gum eucalyptus	Private	6	169
3299	Robusta eucalyptus	Private	4	21
3300	Robusta eucalyptus	Private	21	132

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3301	Robusta eucalyptus	Private	8	139
3302	Robusta eucalyptus	Private	26	138
3303	Robusta eucalyptus	Private	53	748
3304	Robusta eucalyptus	State	51	847
3305	Robusta eucalyptus	State	13	310
3306	Saligna eucalyptus	Other public	18	438
3307	Robusta eucalyptus	Other public	4	69
3308	Paper-bark	Other public	10	(2/)
3309	Robusta eucalyptus	Other public	45	775
3310	Paper-bark	Other public	18	(2/)
3311	Paper-bark	Other public	7	(2/)
3312	Mixed eucalyptus	Private	8	164
3313	Paper-bark	Private	6	(2/)
3314	Robusta eucalyptus	Other public	9	(3/)
3315	Blackbutt eucalyptus	Other public	4	90
3316	Robusta eucalyptus	Other public	42	(3/)
3317	Robusta eucalyptus	Other public	4	90
3318	Robusta eucalyptus	Private	4	90
3319	Robusta eucalyptus	Private	12	270
3320	Robusta eucalyptus	State	8	337
3321	Mixed eucalypts	State	4	12
3322	Robusta eucalyptus	State	15	404
3323	Paper-bark	State	6	(2/)
3324	Molucca albizzia	State	5	37
3325	Turpentine-tree	State	4	37
3326	Robusta eucalyptus	State	14	378
3327	Paper-bark	State	10	(2/)
3328	Robusta eucalyptus	State	5	126
3329	Paper-bark	State	7	(2/)
3330	Ironwood	State	3	(2/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3331	Blackbutt eucalyptus	State	7	82
3332	Paper-bark	State	3	(2/)
3333	Robusta eucalyptus	State	2	54
3334	Paper-bark	State	9	(2/)
3335	Formosa koa	State	6	(2/)
3336	Ironwood	State	12	(2/)
3337	Paper-bark	State	2	(2/)
3338	Robusta eucalyptus	State	15	86
3339	Brushbox	State	7	67
3340	Lemon-gum eucalyptus	State	12	110
3341	Paper-bark	State	8	(2/)
3342	Mixed eucalyptus	State	4	20
3343	Jhalna	State	5	31
3344	Mixed eucalyptus	State	4	20
3345	Mixed eucalyptus	State	7	36
3346	Robusta eucalyptus	State	14	78
3347	Norfolk-Island-pine	State	13	373
3348	Robusta eucalyptus	State	4	28
3349	Jhalna	State	2	13
3350	Paper-bark	State	6	(2/)
3351	Fig	State	3	(2/)
3352	Robusta eucalyptus	Private	4	78
3353	Robusta eucalyptus	Private	3	58
3354	Robusta eucalyptus	Private	4	78
3355	Brushbox	State	4	(3/)
3356	Brushbox	State	7	96
3357	Robusta eucalyptus	State	5	68
3358	Paper-bark	Private	8	(2/)
3359	Robusta eucalyptus	State	4	169
3360	Robusta eucalyptus	State	4	169

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3361	Saligna eucalyptus	Private	45	961
3362	Robusta eucalyptus	State	18	174
3363	Robusta eucalyptus	Private	9	59
3364	Ironwood	Private	3	(2/)
3365	Paper-bark	Private	2	(2/)
3366	Mixed eucalyptus	State	9	7
3367	Mixed hardwoods	State	6	10
3368	Norfolk-Island-pine	Private	3	86
3369	Paper-bark	Private	6	(2/)
3370	Mixed eucalypts	Private	3	2
3371	Mixed eucalypts	Other public	47	425
3372	Paper-bark	Other public	24	(2/)
3373	Paper-bark	Other public	5	(2/)
3374	Brushbox	State	8	67
3375	Robusta eucalyptus	State	14	222
3376	Saligna eucalyptus	State	78	2,160
3377	Robusta eucalyptus	State	4	95
3378	Saligna eucalyptus	State	40	1,909
3379	Blackbutt eucalyptus	State	5	206
3380	Paper-bark	Private	62	(2/)
3381	Blackbutt eucalyptus	Private	4	81
3382	Blackbutt eucalyptus	Private	4	81
3383	Robusta eucalyptus	Private	17	83
3384	Eucalyptus spp.	Private	3	4
3385	Blackbutt eucalyptus	Private	3	61
3386	Blackbutt eucalyptus	Private	3	61
3387	Paper-bark	Private	6	(2/)
3388	Paper-bark	Private	11	(2/)
3389	Saligna eucalyptus	Private	4	83
3390	Saligna eucalyptus	Private	4	83

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3391	Ironwood	Private	13	(2/)
3392	Ironwood	Private	25	(2/)
3393	Norfolk-Island-pine	Private	4	4
3394	Paper-bark	Private	4	(2/)
3395	Norfolk-Island-pine	Private	2	2
3396	Ironwood	Private	13	(2/)
3397	Ironwood	Private	16	(2/)
3398	Ironwood	Private	16	(2/)
3399	Ironwood	Private	32	(2/)
3400	Robusta eucalyptus	Other public	8	156
3401	Paper-bark	Private	3	(2/)
3402	Paper-bark	Private	3	(2/)
3403	Paper-bark	Private	13	(2/)
3404	Norfolk-Island-pine	Private	3	3
3405	Ironwood	Private	2	(2/)
3406	Robusta eucalyptus	Private	8	(2/)
3407	Robusta eucalyptus	Private	3	39
3408	Paper-bark	Private	44	(2/)
3409	Robusta eucalyptus	Private	9	118
3410	Paper-bark	Private	3	(2/)
3411	Robusta eucalyptus	Private	11	35
3412	Robusta eucalyptus	Private	4	52
3413	Robusta eucalyptus	Private	4	52
3414	Mixed eucalypts	Private	4	13
3415	Robusta eucalyptus	Private	4	56
3416	Paper-bark	Private	3	(2/)
3417	Norfolk-Island-pine	Private	9	46
3418	Norfolk-Island-pine	Private	13	245
3419	Brushbox	Private	2	5
3420	Robusta eucalyptus	Private	9	32

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3421	Robusta eucalyptus	Private	4	14
3422	Ironwood	Private	2	(2/)
3423	Ironwood	Private	6	(2/)
3424	Robusta eucalyptus	Private	8	67
3425	Ironwood	Private	3	(2/)
3426	Ironwood	Private	2	(2/)
3427	Ironwood	Private	5	(2/)
3428	Robusta eucalyptus	Private	6	(3/)
3429	Ironwood	Other public	20	(2/)
3430	Bluegum eucalyptus	Private	8	(2/)
3431	Robusta eucalyptus	State	2	32
3432	Saligna eucalyptus	State	3	99
3433	Robusta eucalyptus	State	4	29
3434	Robusta eucalyptus	State	4	65
3435	Brushbox	State	3	29
3436	Robusta eucalyptus	State	4	65
3437	Ironwood	Private	9	(2/)
3438	Ironwood	Private	3	(2/)
3439	Paper-bark	Private	9	(2/)
3440	Mixed eucalypts	Private	3	69
3441	Saligna eucalyptus	Private	5	64
3442	Mixed eucalypts	Private	5	115
3443	Mixed eucalypts	State	2	46
3444	Mixed eucalypts	State	7	74
3445	Brushbox	State	11	86
3446	Brushbox	State	2	(3/)
3447	Silk-oak	Private	4	3
3448	Robusta eucalyptus	Private	3	44
3449	Silk-oak	Private	4	(3/)
3450	Robusta eucalyptus	Private	7	146

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3451	Ironwood	Private	4	(2/)
3452	Ironwood	Private	12	(2/)
3453	Ironwood	Private	3	(2/)
3454	Ironwood	Private	8	(2/)
3455	Norfolk-Island-pine	State	17	29
3456	Ironwood	State	2	(2/)
3457	Brushbox	State	3	(3/)
3458	Ironwood	State	3	(2/)
3459	Ironwood	State	16	(2/)
3460	Norfolk-Island-pine	State	11	11
3461	Turpentine-tree	State	3	(3/)
3462	Silk-oak	Private	2	(3/)
3463	Robusta eucalyptus	Other public	12	60
3464	Brushbox	Other public	5	4
3465	Paper-bark	Other public	23	(2/)
3466	Robusta eucalyptus	State	3	49
3467	Ironwood	Other public	55	(2/)
3468	Ironwood	Other public	7	(2/)
3469	Blackbutt eucalyptus	Private	3	70
3470	Blackbutt eucalyptus	Private	4	94
3471	Robusta eucalyptus	Private	3	15
3472	Brushbox	Private	4	38
3473	Robusta eucalyptus	Other public	3	11
3474	Blackbutt eucalyptus	Private	25	585
3475	Mixed eucalypts	Private	4	65
3476	Eucalyptus spp.	Private	2	32
3477	Jhalna	Private	2	13
3478	Eucalyptus spp.	Private	3	49
3479	Norfolk-Island-pine	State	25	967
3480	Norfolk-Island-pine	State	4	155

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3481	Australian kauri	State	4	21
3482	Blackbutt eucalyptus	State	3	70
3483	Robusta eucalyptus	Private	4	36
3484	Molucca albizzia	Private	4	5
3485	Molucca albizzia	Private	3	47
3486	Eucalyptus spp.	State	3	(3/)
3487	Eucalyptus spp.	Private	2	14
3488	Mixed eucalypts	Private	3	27
3489	Blackbutt eucalyptus	Private	4	81
3490	West Indies mahogany	State	2	4
3491	Silk-oak	State	3	6
3492	Ironwood	State	9	(2/)
3493	Saligna eucalyptus	State	4	111
3494	Blackbutt eucalyptus	State	4	165
3495	Ironwood	State	8	(2/)
3496	Robusta eucalyptus	State	2	11
3497	Australian toon	State	3	100
3498	Mixed eucalypts	State	5	44
3499	Mixed eucalypts	State	4	20
3500	Lemon-gum eucalyptus	State	3	126
3501	Gray ironbark eucalyptus	State	4	33
3502	Eucalyptus spp.	State	2	10
3503	Mixed eucalypts	State	4	39
3504	Ironwood	Private	25	(2/)
3505	Ironwood	State	13	(2/)
3506	Monkey-pod	State	7	120
3507	Mixed eucalypts	State	14	70
3508	Ironwood	State	2	(2/)
3509	Silk-oak	State	5	52
3510	Brushbox	State	4	31

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3511	Gray ironbark eucalyptus	State	8	(3/)
3512	Gray ironbark eucalyptus	State	8	(3/)
3513	Brushbox	Private	8	29
3514	Paper-bark	Private	8	(2/)
3515	Norfolk-Island-pine	Private	2	57
3516	Lemon-gum eucalyptus	Private	2	2
3517	Turpentine-tree	Private	4	2
3518	Turpentine-tree	Private	2	(3/)
3519	Brushbox	Private	2	(3/)
3520	Gray ironbark eucalyptus	Private	2	(3/)
3521	Brushbox	Private	2	(3/)
3522	Mixed eucalypts	State	9	250
3523	Norfolk-Island-pine	State	2	57
3524	Paper-bark	State	22	(2/)
3525	Paper-bark	State	5	(2/)
3526	Robusta eucalyptus	State	2	11
3527	Jhalna	State	2	(3/)
3528	Robusta eucalyptus	State	18	1,036
3529	Brushbox	State	20	34
3530	Blackbutt eucalyptus	State	14	157
3531	Turpentine-tree	State	5	65
3532	Brushbox	State	9	88
3533	Paper-bark	State	5	(2/)
3534	Brushbox	State	10	123
3535	Ironwood	State	7	(2/)
3536	Norfolk-Island-pine	State	14	303
3537	Ironwood	State	2	(2/)
3538	Turpentine-tree	State	4	37
3539	Ironwood	State	5	(2/)
3540	Brushbox	State	3	29

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3541	Paper-bark	State	2	(2/)
3542	Mixed eucalypts	Private	35	232
3543	Brushbox	Private	7	19
3544	Mixed eucalypts	State	4	27
3545	Mixed eucalypts	State	3	20
3546	Mixed eucalypts	Private	4	27
3547	Brushbox	Private	9	44
3548	Brushbox	Private	4	20
3549	Brushbox	Private	2	5
3550	Brushbox	State	4	11
3551	Gray ironbark eucalyptus	Private	6	21
3552	Silk-oak	State	2	(3/)
3553	Silk-oak	State	5	(3/)
3554	Silk-oak	State	3	(3/)
3555	Silk-oak	State	4	(3/)
3556	Silk-oak	State	7	(3/)
3557	Mixed eucalypts	State	3	3
3558	Mixed eucalypts	Private	3	1
3559	Saligna eucalyptus	State	2	40
3560	Tallowwood eucalyptus	State	2	40
3561	Gray ironbark eucalyptus	State	4	(3/)
3562	Gray ironbark eucalyptus	State	3	(3/)
3563	Mixed eucalypts	State	3	3
3564	Mixed eucalypts	Private	3	49
3565	Ironwood	Private	18	(2/)
3566	Brushbox	Private	3	17
3567	Robusta eucalyptus	State	6	18
3568	Gray ironbark eucalyptus	State	7	19
3569	Gray ironbark eucalyptus	State	9	24
3570	Ironwood	State	2	(2/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3571	Robusta eucalyptus	State	3	9
3572	Brushbox	State	12	(3/)
3573	Brushbox	State	3	15
3574	Mixed eucalypts	State	2	6
3575	Gray ironbark eucalyptus	State	3	11
3576	Brushbox	State	3	15
3577	Silk-oak	State	3	(3/)
3578	Gray ironbark eucalyptus	State	4	11
3579	Gray ironbark eucalyptus	State	6	23
3580	Ironwood	Private	2	(2/)
3581	Ironwood	Private	18	(2/)
3582	Ironwood	Private	5	(2/)
3583	Robusta eucalyptus	Private	4	66
3584	Ironwood	Private	3	(2/)
3585	Ironwood	Private	63	(2/)
3586	Ironwood	Private	15	(2/)
3587	Robusta eucalyptus	Private	3	56
3588	Ironwood	Private	3	(2/)
3589	Robusta eucalyptus	Private	3	56
3590	Robusta eucalyptus	Private	3	56
3591	Blackbutt eucalyptus	Private	4	81
3592	Robusta eucalyptus	Private	2	38
3953	Lemon-gum eucalyptus	State	3	10
3594	Paper-bark	State	3	(2/)
3595	Paper-bark	State	2	(2/)
3596	Blackbutt eucalyptus	Private	2	41
3597	Paper-bark	Private	6	(2/)
3598	Blackbutt eucalyptus	Private	3	61
3599	Paper-bark	Private	7	(2/)
3600	Mixed hardwoods	State	3	7

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3601	Saligna eucalyptus	State	4	111
3602	Saligna eucalyptus	State	3	83
3603	Paper-bark	Private	9	(2/)
3604	Brushbox	State	3	3
3605	Brushbox	Other public	2	2
3606	Mixed eucalypts	Other public	2	18
3607	Mixed eucalypts	Other public	4	36
3608	Paper-bark	State	4	(2/)
3609	Brushbox	Private	3	(3/)
3610	Paper-bark	Private	4	(2/)
3611	Blackbutt eucalyptus	Private	2	36
3612	Saligna eucalyptus	State	2	55
3613	Turpentine-tree	State	3	28
3614	Saligna eucalyptus	State	3	83
3615	Saligna eucalyptus	State	4	111
3616	Blackbutt eucalyptus	State	3	124
3617	Blackbutt eucalyptus	State	4	165
3618	Ironwood	Private	14	(2/)
3619	Ironwood	Private	6	(2/)
3620	Robusta eucalyptus	Private	4	39
3621	Robusta eucalyptus	Private	3	(3/)
3622	Robusta eucalyptus	Private	3	29
3623	Robusta eucalyptus	State	4	65
3624	Brushbox	State	3	3
3625	Eucalyptus spp.	State	4	65
3626	Robusta eucalyptus	Private	2	42
3627	Ironwood	State	13	(2/)
3628	Norfolk-Island-pine	State	2	3
3629	Mixed eucalypts	State	3	3
3630	Mixed eucalypts	State	4	24

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3631	Paper-bark	State	3	(2/)
3632	Brushbox	State	2	25
3633	Eucalyptus spp.	State	2	(2/)
3634	Paper-bark	State	3	(2/)
3635	Paper-bark	State	3	(2/)
3636	Paper-bark	State	4	(2/)
3637	Formosa koa	State	13	(2/)
3638	Ironwood	State	8	(2/)
3639	Robusta eucalyptus	State	3	75
3640	Robusta eucalyptus	State	3	81
3641	Turpentine-tree	State	2	19
3642	Brushbox	State	2	13
3643	Brushbox	Other public	4	7
3644	Brushbox	Other public	4	7
3665	Turpentine-tree	Other public	3	28
3646	Brushbox	Other public	3	5
3647	Brushbox	Other public	3	5
3648	Brushbox	Other public	3	5
3649	Paper-bark	Other public	8	(2/)
3650	Paper-bark	Other public	19	(2/)
3651	Ironwood	Other public	44	(2/)
3652	Formosa koa	Other public	7	(2/)
3653	Brushbox	Other public	4	7
3654	Brushbox	Other public	4	(3/)
3655	Eucalyptus spp.	Other public	3	5
3656	Brushbox	Other public	2	2
3657	Molucca albizzia	Other public	2	2
3658	Eucalyptus spp.	Other public	4	6
3659	Ironwood	Other public	9	(2/)
3660	Molucca albizzia	Other public	2	31

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3661	Jhalna	Other public	2	13
3662	Molucca albizzia	Other public	2	2
3663	Ironwood	Other public	96	(2/)
3664	Paper-bark	Other public	6	(2/)
3665	Paper-bark	Other public	4	(2/)
3666	Paper-bark	State	6	(2/)
3667	Paper-bark	State	4	(2/)
3668	Paper-bark	State	4	(2/)
3669	Paper-bark	State	9	(2/)
3670	Paper-bark	Other public	5	(2/)
3671	Formosa koa	Other public	3	(2/)
3672	Brushbox	Other public	4	7
3673	Eucalyptus spp.	Private	2	32
3674	Brushbox	Private	4	3
3675	Brushbox	Private	2	19
3676	Blackbutt eucalyptus	State	2	27
3677	Turpentine-tree	State	2	19
3678	Brushbox	Private	3	3
3679	Eucalyptus spp.	State	2	27
3680	Eucalyptus spp.	State	2	27
3681	Paper-bark	State	5	(2/)
3682	Molucca albizzia	State	2	31
3683	Molucca albizzia	Other public	4	63
3684	Norfolk-Island-pine	State	3	86
3685	Eucalyptus spp.	State	2	10
3686	Molucca albizzia	State	3	47
3687	Robusta eucalyptus	State	2	54
3688	Robusta eucalyptus	Private	4	12
3689	Robusta eucalyptus	Private	4	12
3690	Robusta eucalyptus	Private	3	9

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
3691	Ironwood	Private	11	(2/)
3692	Ironwood	State	2	(2/)
3693	Ironwood	State	2	(2/)
3694	Mango	State	4	5
3695	Ironwood	State	27	(2/)
3696	Brushbox	Private	4	(3/)
3697	Gray ironbark eucalyptus	Private	4	(3/)
3698	Gray ironbark eucalyptus	Private	3	5
3699	Paper-bark	Private	2	(2/)
3700	Paper-bark	Private	3	(2/)
3701	Robusta eucalyptus	Private	2	6
3702	Ironwood	Private	8	(2/)
3703	Brushbox	Private	2	(3/)
3704	Mixed eucalypts	Private	4	12
3705	Ironwood	Private	12	(2/)
Total			6,837	45,826

See footnotes at end of Table.

Table 11, continued

AREAS REFORESTED 1950-66 [5/]

Stand No.	Species type	Owner	Acres	Total stand volume
				Thousand board feet
	Kawailoa area:			
--	Eucalyptus spp.	Private	2	(3/)
--	Robusta eucalyptus [6/]	Private	3	(3/)
--	Mixed pines	Private	10	(3/)
--	Mixed hardwoods	Private	16	(3/)
	Total Kawailoa		31	--
	Mokuleia area:			
--	Saligna eucalyptus	State	8	(3/)
--	Norfolk-Island-pine	State	27	(3/)
--	Tropical ash	State	9	(3/)
--	Brushbox	State	3	(3/)
--	Mixed hardwoods	State	19	(3/)
	Total Mokuleia		66	--
	Honolulu area:			
--	Mixed hardwoods	State	6	(3/)
	Waianae-Kai area:			
--	Saligna eucalyptus	State	5	(3/)
	Kuaokala area:			
--	Saligna eucalyptus	State	29	(3/)
	Total		137	--
	Total forest plantations		6,974	45,826

1/ Stand numbers 3001, 3132, and 3172 not used.
2/ Noncommercial plantation type.
3/ Poletimber or seedling and sapling stands.
4/ In this table, refers to military or county and municipal lands.
5/ No stand numbers assigned.
6/ Natural regeneration.

Table 12.--Identity of individual plantation stands in the groups shown on the map "Forest Plantations on the Island of Oahu--1966"[1/]

Group stand No.	Individual stand No.	Group stand No.	Individual stand No.
1	3552-57	21	3275-78; 3580-90, 92
2	3012-13; 3559-60	22	3267-73
3	3002, 14-16; 3561-62	23	3182-83, 87-89, 91; 3250-59, 74, 7988; 3489; 3591, 95-99
4	3017; 3558	24	3220-25, 29, 31-35, 37-39
5	3005-11, 23, 51, 62, 68, 70; 3117	25	3210-15
6	3018-22, 24-28	26	3171, 73-74, 76-80
7	3029, 30	27	3207-9; 3483, 88
8	3031-32	28	3200-6, 97-98
9	3033-37, 40-45, 47-48, 50, 52, 54-61, 63-67, 69, 71-74, 77-79, 80-82; 3260-61	29	3192-99
10	3038-39, 83-87	30	3289-93
11	3004, 46, 76, 89-99; 3100-4, 29	31	3299; 3300-3, 12-13
12	3003, 88; 3105-16, 18-20; 3216-19, 26-27, 30, 36, 94-96; 3405, 47	32	3306-11, 15-19
13	3121, 23-28, 30-31; 3448-49, 62	33	3075; 3122, 75; 3228, 40; 3304-5, 25, 52-54, 68-90; 3400, 93-94; 3600-17
14	3133-58; 3474	34	3391-99; 3401-4
15	3160	35	3618-19
16	3159, 61-62	36	3361-65; 3406, 40-43
17	3163-69	37	3407-16
18	3170	38	3417-24
19	3181	39	3425-26
20	3184-86, 90; 3241-49; 3593-94	40	3262-66; 3338-40; 3427-39, 69-72, 74, 86; 3621-25

Table 12, continued

Group stand No.	Individual stand No.	Group stand No.	Individual stand No.
41	3444-46; 3510-12	56	3320-24, 26-29, 31-37, 41-46, 66-67; 3509, 23-27; 3685
42	3450-54; 3626	57	3688
43	3455-61; 3627	58	3534; 3686-87
44	3463-65, 67-68	59	3689-91
45	3479-82; 3628-32	60	3513-21
46	3484-85, 87	61	3542-46, 49-50; 3694
47	3330; 3490-92, 95-99, 3500-8	62	3695-99; 3700
48	3347; 3466; 3522; 3633-42	63	3692-93
49	3563-66, 75-78; 3673-75	64	3547-48, 51, 68-79
50	3529-30; 3643-72	65	3701-5
51	3355-58; 3676-78		
52	3359-60; 3679-81		
53	3535-41		
54	3528, 31-33, 3682-83		
55	3348-51; 3684		

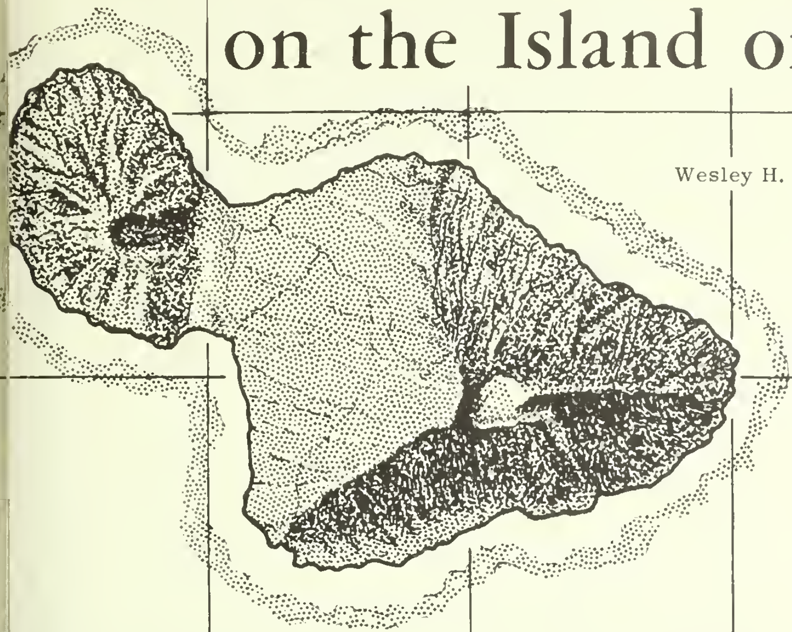
1/ Unnumbered stands on the map are identified by symbols as follows:

KRP--Kuaokala reforestation planting, 1950-66; includes seedling, sapling, and poletimber.
HRP--Honolulu reforestation planting, 1950-66; includes seedling, sapling, and poletimber.
MRP--Mokuleia reforestation planting, 1950-66; includes seedling, sapling, and poletimber.
WRP--Waianae-Kai reforestation planting, 1950-66; includes seedling, sapling, and poletimber.
ORP--Opaeula reforestation planting, 1950-66; includes seedling, sapling, and poletimber.

GPO 976-713

U. S. D.A. FOREST SERVICE
RESOURCE BULLETIN
PSW - 11 1969

Plantation Timber on the Island of Maui--1967



Wesley H. C. Wong, Jr. Herbert L. Wick Robert E. Nelson

Pacific Southwest Forest and Range
Experiment Station, Forest Service,
U.S. Department of Agriculture,
Berkeley, California 94701

and

Division of Forestry,
Department of Land and
Natural Resources,
State of Hawaii,
Honolulu, Hawaii 96813

Foreword

This report is the last of a series about planted forests on major islands in the State of Hawaii. Reports have been published for the islands of Hawaii (1966), Kauai (1967), Lanai (1967), Molokai (1968), and Oahu (1968). Summarized here are the results of a survey of timber in planted forests on the Island of Maui. This inventory supplements the initial Forest Survey of the State completed in 1963. That survey indicated the importance of planted forests as a timber resource, but provided no details. This bulletin reports: (a) location and acreage of each planted stand, (b) species composition and age of stand, (c) timber volume and quality, and (d) ownership of planted timber.

The study is a cooperative undertaking of the Division of Forestry, Hawaii Department of Land and Natural Resources, and of the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. It was conducted under the direction of Robert E. Nelson, Director, Institute of Pacific Islands Forestry, Pacific Southwest Forest and Range Experiment Station. Nobuo Honda, Forester, Hawaii Division of Forestry, helped develop plans for the plantation inventory.

In 1966, responsibility for supervision of the Forest Survey in the Pacific Coast States and Hawaii was assigned to the Pacific Northwest Forest and Range Experiment Station, but field work in Hawaii will continue to be a joint effort of the Hawaii State Division of Forestry and the Pacific Southwest Forest and Range Experiment Station.

Many individuals aided in various phases of the survey. Special acknowledgment is due the field crew: Forester Wesley Wong and crew members Kazuo Tamura and Jacob Mau, Jr.—all of the Hawaii Division of Forestry.

E. M. Hornibrook, formerly in charge of the Forest Survey, Pacific Southwest Station, and Russell K. LeBarron, former Forest Ecologist, Hawaii Division of Forestry, aided in developing plans for the study.

Robert M. Miller, Systems Analyst, Pacific Southwest Station, developed specifications for automatic data processing. The computing center at the University of Hawaii processed the data.

Karl H. Korte, District Forester, Maui, and Tom K. Tagawa, State Forester, provided generous cooperation in the conduct of the survey.

U.S. Forest Service research in Hawaii is conducted in cooperation with the Division of Forestry, Hawaii Department of Land and Natural Resources.

Contents

The Authors

WESLEY H. C. WONG, Jr., a native of Wailuku, Maui, received his bachelor's degree in forestry from Oregon State University in 1964. As timber survey forester for the Hawaii Division of Forestry, he has been assigned primarily to the forest inventory of the State. HERBERT L. WICK is working on mensuration problems and forest survey techniques. A native of Seattle, Washington, he earned a bachelor's and master's degree in forestry at the University of Washington. He worked 3 years in the Pacific Northwest with the Forest Service before joining the staff of the Institute of Pacific Islands Forestry in 1967. ROBERT E. NELSON directs the Pacific Southwest Station's Institute of Pacific Islands Forestry, headquartered in Honolulu. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office.

Eucalyptus robusta comprises most of the sawtimber volume on Maui. This 65-year-old robusta stand (No 6114) in the Koolau Forest Reserve averages nearly 70,000 board feet of sawtimber per acre.

Maui, second largest of the Hawaii Islands, holds some of the finest agricultural lands in the State. Sugar production is the most important industry there. Pineapple and truck farming are also important activities on the island.

Two separate volcanic mountain ranges joined by a low isthmus form this 728-square-mile island. The west side is geologically older. The mountains there are ruggedly dissected, with several peaks rising over 5,000 feet. On the windward side, the steep ridges and canyons drop sharply into the sea. On the leeward, or westerly, side of western Maui, geologic processes have developed a sloping coastal plain, dissected by streams.

On the east side, Mount Haleakala rises to 10,023 feet. Now dormant, Haleakala last erupted in 1750. The molten lava added to the crusty southern fringe of the island. The volcano's rugged and lushly forested windward slopes also terminate in steep sea cliffs. The leeward slopes are also steep but not so ruggedly dissected. These dry, southwest slopes are sparsely vegetated --only a few shrubs and herbaceous plants grow. The upper slopes and summit area of Haleakala are rocky and nearly barren of vegetation.

Cattle graze on a large acreage throughout much of Maui. Although much of the grazed land is forested, grazing is excluded from much of the Forest Reserves.

Tourism is important to the island's economy. Maui's historic Lahaina Coast, scenic Hana, and Mount Haleakala (considered the legendary house of the sun) attract thousands of tourists annually.

More than half of Maui is forest land.[1] Of the 466,000 acres, 120,000 acres are commercial forest land holding about 108 million board feet of sawtinber (figs. 1,2). In addition, there are about 143,000 acres of noncommercial forest land, and 40,000 acres of nonforest rockland and pali.

Forest Reserves amount to 159,000 acres,[2] mostly in the mountainous areas. The Reserves are public and private lands administered by the State for management and protection of watershed and other forest values. However, private lands in Reserves and not under surrender agreement do not receive management, but only protection and zoning.

---

[1]Nelson, Robert E., and Wheeler, Philip R. *Forest Resources of Hawaii--1961*. Forestry Div., Dep. Land and Natural Resources, State of Hawaii, in cooperation with the Pacific SW. Forest & Range Exp. Sta., Forest Serv., U.S. Dep. Agr., 48 p., illus. 1963.

[2]Hawaii Dep. Land and Natural Resources. Report to the Governor--July 1, 1966 to June 30, 1967. 83 p., illus. 1967.

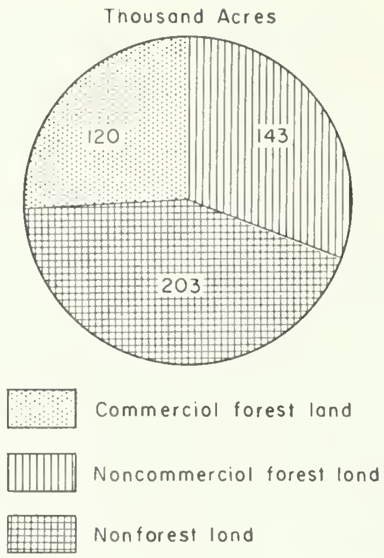


Figure 1.--Forest and nonforest land acreages on the Island of Maui, 1961.

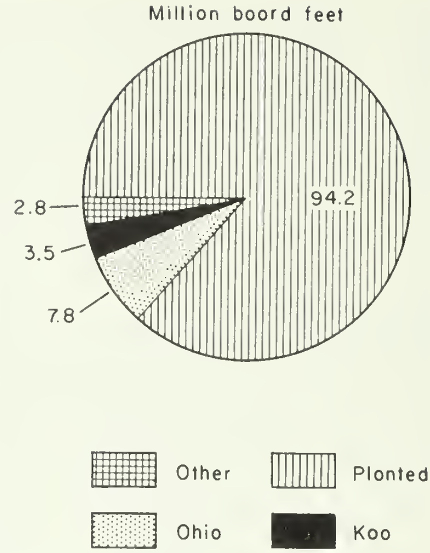


Figure 2.--Sawtimber volumes on the Island of Maui. (Planted figure is current volume; others are 1961 data.)

Most of the commercial forest land has a cover of native or naturalized types, but they hold little volume of sawtimber. Only about 21,000 acres of ohia (*Metrosideros collina*), koa (*Acacia koa*),[3] or naturalized types were considered commercial types in the initial Forest Survey.[4] Sawtimber stocking averages about 670 board feet per acre for a total of only 14 million board feet. Noncommercial forest or brush types occupy nearly 96,000 acres of the commercial forest land.

Forest plantings were started on Maui by ranchers and sugar companies in the late 1800's for the production of fuelwood, fenceposts, and timber; for erosion control, shelterbelts, and shade; and for esthetic purposes. The Territorial Division of Forestry, assisted by the Civilian Conservation Corps, greatly expanded reforestation efforts in the 1930's. They concentrated on providing a vegetative cover to protect watersheds. Since 1960, the Division of Forestry has accelerated its reforestation program.

Although the acreage of planted forests on Maui is small, they hold six times more volume of sawtimber than native forests. And timber yield and quality are higher. The total volume of plantation timber is 94 million board feet. Most is readily accessible and has a good potential for industrial use.

In 1967, we started a stand-by-stand inventory to obtain detailed information on plantation acreage, timber volume and quality, and ownership. This report summarizes data compiled for each plantation stand.

---

[3]A small acreage of planted koa forest is included in the over-all acreage of the native forest type because of the difficulty of differentiation. In general, the planted koa forest has not developed into good timber stands.
[4]Nelson and Wheeler. Op. cit.

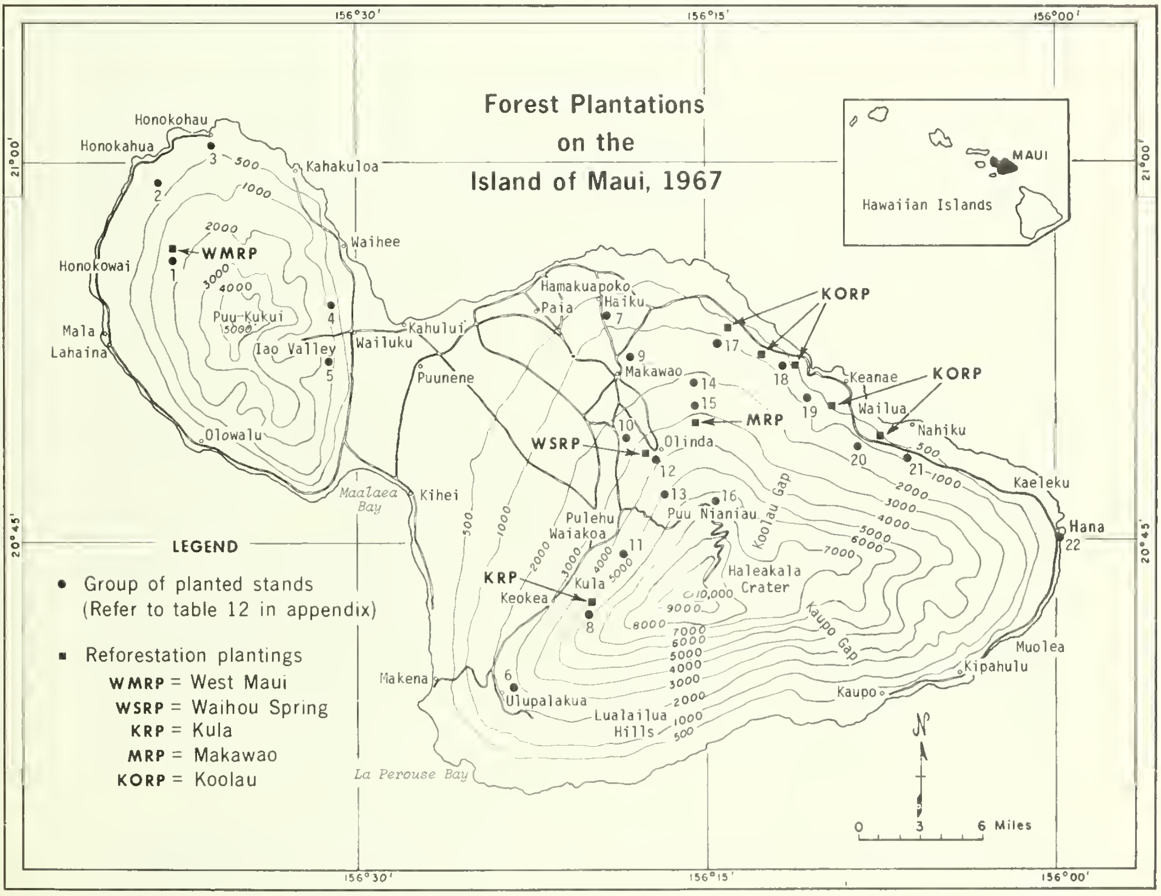
Plantation Timber Resource

Area

Forest plantations on Maui total more than 10,000 acres. This includes commercial forest types,[5] such as robusta eucalyptus, and noncommercial types, such as paper-bark. Most forest plantations are concentrated in two general areas on the west and northwesterly slopes of Haleakala (see map and tables 1-4, 11, and 12). Small plantings lie next to cultivated and pasture areas, in gullies, and on steep slopes on nearly all parts of of the island. These scattered plantings make up a significant portion of the forest plantation resource.

We inventoried 6,063 acres of commercial forest plantations on the Island of Maui, in stands from 2 acres to 120 acres in size (tables 1-4; fig. 3). Most of the individual stands tallied are small. Only 20 were 50 acres or larger for a total of 1,660 acres; stands 5 to 49 acres in size aggregated 4,167 acres; and 75 stands from 2 to 4 acres in size totaled 236 acres.

[5]See definitions of terms in appendix.



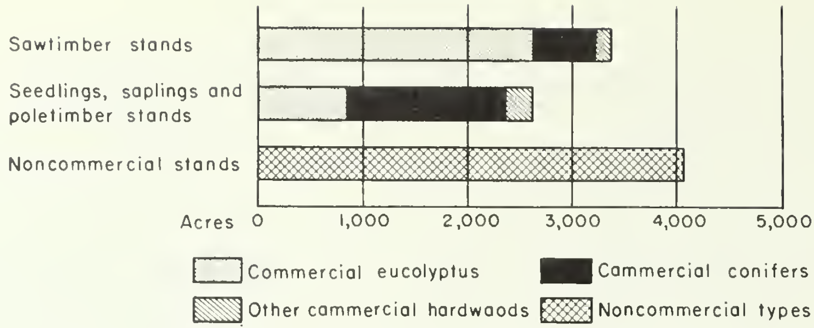


Figure 3.--Acreage of commercial and noncommercial plantation stands by stand-size class and forest type, Island of Maui, 1967.

About 3,400 acres of the commercial forest plantations are sawtimber stands. Another 2,660 acres are recently planted seedling, sapling, and poletimber stands of commercial species. Of this acreage, 1,500 acres are conifers and 1,160 acres are hardwoods.

Eucalypts, mainly *Eucalyptus robusta*, make up 77 percent, or nearly 2,630 acres of the sawtimber stands. Hardwood sawtimber stands other than eucalypts total 170 acres; and there are over 600 acres of commercial conifer sawtimber stands.

In addition to the commercial forest plantations, there are about 4,060 acres of noncommercial types, mostly paper-bark, bluegum eucalyptus, and ironwood.

Volume

Forest plantations on Maui contain about 94 million board feet of sawtimber (tables 5-8). Of this volume about 92 million board feet are in stands 5 acres and larger; 2 million board feet are in stands 2 to 4 acres in size.

Sawtimber includes 82 million board feet of eucalyptus of which robusta eucalyptus alone accounts for 72.7 million board feet (fig. 4). Other volume in hardwoods totals only 1.5 million board feet. Commercial conifer sawtimber totals 10.6 million board feet, mostly redwood and Norfolk-Island-pine.

In the stands 5 acres and larger, about 54 percent of the sawtimber volume is in trees 19 to 29 inches d.b.h. (table 8); 27 percent in trees smaller than 19 inches d.b.h.; and 19 percent in trees 29 inches d.b.h. and larger.

Growing stock volume in planted sawtimber stands amounts to about 18 million cubic feet (tables 5-8). About 85 percent or 15.5 million cubic feet is in eucalypts—robusta eucalyptus alone totaling some 13.4 million cubic feet. Other hardwoods account for only 0.4 million cubic feet. In conifers, mostly redwood, there are 2.2 million cubic feet.

An additional volume of growing stock is in the poletimber, sapling, and seedling stands, but they were not measured.

Wood in cull trees in planted sawtimber stands 5 acres and larger totals about 886,000 cubic feet (table 9). Sawtimber stands of 2 to 4 acres in size and the 4,060 acres of noncommer-

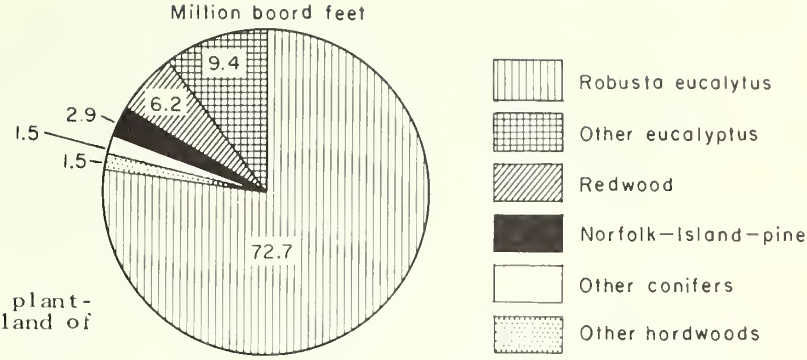


Figure 4.--Sawtimber volume in planted stands by species group, Island of Maui, 1967.

cial plantations hold an additional volume of wood in cull trees, but these stands were not measured. Wood from some trees now considered noncommercial species may have some potential for industrial use.

Ownership

The State of Hawaii owns 5,076 acres, or nearly half of the total forest plantation acreage on Maui (tables 2,3,11). The remainder, except for 4 acres of noncommercial type in Federal holdings, is privately owned.

A little over half, or 2,792 acres of the State-owned forest plantations are commercial types; 2,284 acres are noncommercial types.

Private holdings of commercial forest types total 3,271 acres. Noncommercial types in private ownership amount to 1,776 acres.

In volume, the State owns only 15 percent (13.5 million board feet) of the timber because a substantial portion of its plantations are the younger seedling, sapling, and pole-size stands (tables 6,7,10,11). A large portion of the private plantations are sawtimber size with higher yields: 85 percent or 78.5 MMBF.

Age of Stands

The 2,040 acres of commercial forest plantation stands more than 40 years old (table 4) were planted in the late 1800's and early 1900's, primarily for fuel, fence posts, shelterbelts and erosion control. Commercial stands planted from 1926 to 1945 total 1,713 acres. Much of this acreage was planted between 1935 and 1941 by the Civilian Conservation Corps. Between 1946 and 1967, 2,310 acres were planted. The bulk of this acreage has been planted by the State Division of Forestry since the early 1960's.

There are 1,647 acres of noncommercial plantations more than 40 years old and 2,417 acres less than 40 years old.

Stand Yields

Stand yields differ greatly with stand age, species, site, history and condition of stand, and other factors. The average volume of sawtimber in the planted sawtimber stands on Maui is 27,700 board feet per acre. The highest average net volume measured was 80,200 board feet per acre in a robusta eucalyptus stand about 60 years old (stand No. 6146; see table 11). The next highest was in a stand of robusta eucalyptus yielding about 77,500 board feet per acre (stand No. 6118; see table 11).

Timber Quality

Bangalay eucalyptus sawtimber excels other species in quality, based on its proportion of volume in grades 1 and 2 factory lumber logs. Twenty-seven percent of the Bangalay eucalyptus sawtimber is in grade 1, and 17 percent in grade 2 logs (table 10). Robusta eucalyptus, the hardwood species in greatest volume, has 25 percent of its volume in grade 1 and 12 percent in grade 2 logs. Conifer species were not log-graded.

Opportunity for Industrial Development

Most of Maui's native or naturalized forests are not merchantable timber types and are often just brush. These poorly stocked or nonstocked commercial forest lands contain only small amounts of merchantable timber. Only 21,000 of the 116,000 acres of native or naturalized forest types are considered merchantable timber types, and these forests hold only about 14 million board feet of sawtimber.

Although continued harvesting of small amounts of fence posts, fuelwood, and miscellaneous products from native forests is likely, practically none of the native stands offers prospects for sawtimber harvest.

Planted forests, in contrast to the native forests, have grown rapidly and now yield high volumes of timber. Most of the tree planting that produced this timber resource was not done primarily to grow sawtimber. Instead, trees were planted to control erosion, improve watershed cover, and provide fuelwood. Therefore, species planted were not necessarily selected on the basis of wood quality, but on the basis of adaptability and rapid growth. *Eucalyptus robusta* was highly favored; so were several species that now offer little or no potential for sawtimber, such as ironwoods (*Casuarina* spp.) and paper-bark (*Melaleuca leucadendron*).

Some of these early plantings demonstrate that timber production potentials are far greater than might be inferred from the data on present total sawtimber volumes. We know that many valuable introduced timber species are adapted to the different forest sites. Timber yields can be prodigious. Under management, an average annual sawtimber growth rate of 1,000 board feet per acre can be expected from well-stocked forests on good sites. And stands can be harvested within 30 to 50 years after establishment.

The present timber resource is large enough to support a small sawmilling industry. And it has the potential to develop into a much larger timber resource as a base for a significant local industry. Such an industry will depend upon the expansion of local markets and perhaps export markets for the specialized products for which the timber is useful.

If only 20 percent of the 120,000 acres of presently little-used and unmanaged commercial forest land were planted to introduced species and managed, timber production could amount to about 24 million board feet annually in 30 years. This potential is significant considering that Hawaii now imports each year some 100 million feet of wood.

Recent forestation efforts by the State are in part an attempt to capitalize on this potential. Species are being selected with consideration for wood qualities and adaptability to specific sites. Plantings are made in large blocks on nonstocked lands or lands where the present forests are of particularly poor quality.

Since 1956, about 1,800 acres of land on Maui have been forested by the State Division of Forestry. Forestation efforts should be expanded. The amount of forestation accomplished during the next 10 years will determine in large part the amount of harvestable timber that might be available 30 to 40 years from now as a base for an expanded industry.

Multiple Values of Forests

Forests provide many values besides timber. On Maui, their value for watershed protection and for recreation use exceeds their value for timber. Plantations established primarily for watershed protection and erosion control have greatly improved the landscape and increased forest recreation opportunities. Planted forests of introduced trees now provide the most attractive and heavily used forest recreation sites on the island. They also can provide improved wildlife habitat. These multiple benefits of planted forests accrue continuously year after year. In addition, timber can be harvested periodically without detracting from, and often enhancing, the recreation and watershed values.

Because vast acreages of mountain lands on Maui must be maintained in forest cover, public land managers and private owners, too, should develop all the potential benefits latent in these lands. For it has been demonstrated in the existing plantations that forestation can enhance recreation use, watershed value, timber production, and wildlife habitat.

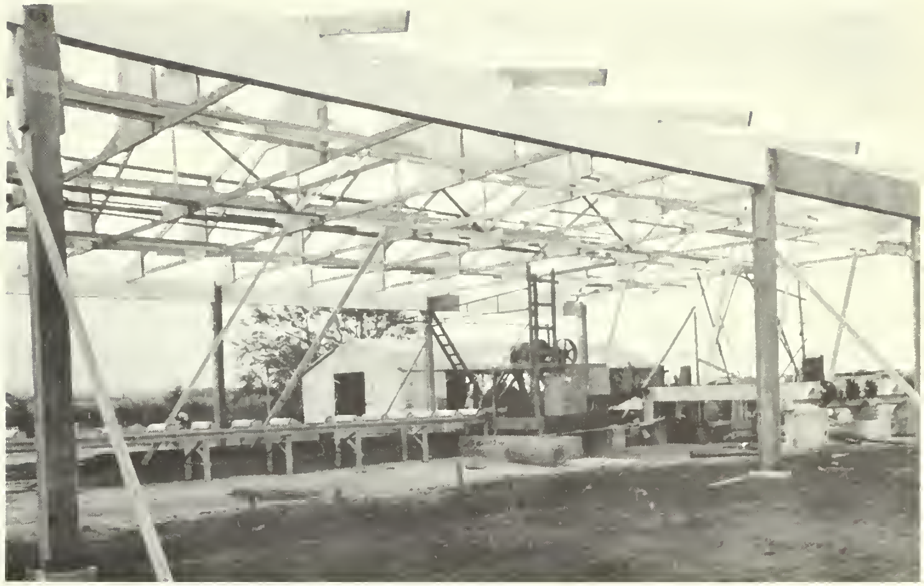
Potential of Maui's forests is illustrated by these three species: (A) 7-year-old stand of saligna eucalyptus, a species highly favored in recent reforestation; (B) 35-year-old redwood stand holding more than 72,000 board feet per acre--a species excelling all other conifers in sawtimber volume; (C)planted Norfolk-Island-pine stand in the Haiku area that averages 76,000 board feet per acre of sawtimber.

A

B

C

·w sawmill on Maui has been designed
ɔrcess timber from planted forests.



Shelterbelts of eucalypts help protect pineapple fields on exposed areas.

lanted forests of mixed species provide
ecreation sites, such as Kaumahina State
ark near Keanae, developed by the Hawaii
ivision of Forestry.

Appendix

Definitions

Commercial and Noncommercial

Forest land: Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover and not currently developed for other use; and land supporting shrubs, the crowns covering more than 50 percent of the ground

> *Commercial forest land:* Forest land that is producing or can produce crops of industrial wood (usually sawtimber) and is not withdrawn from timber use.

> *Noncommercial forest land:* (a) *Productive-reserved* forest land withdrawn from timber use through statute or administrative regulation, and (b) *unproductive* forest land incapable of yielding crops of industrial wood because of adverse site conditions.

Forest plantation: Planted forests in which at least 10 percent of the growing space is occupied by planted trees (introduced species in this report), regardless of native species predominance.

> *Commercial forest plantation:* A plantation of commercial tree species on commercial forest land.

> *Noncommercial forest plantation:* A plantation of noncommercial tree species or of commercial tree species planted on noncommercial forest land.

Commercial tree species: Tree species suitable for industrial wood products. Species suited only for fuelwood or fence posts are excluded. The following commercial tree species were tallied on plots:

Scientific Name	*Common Name*
Acacia koa	koa
Albizia falcata (A. moluccana)	Molucca albizzia
Araucaria cunninghamii	hoop-pine
Araucaria excelsa	Norfolk-Island-pine
Chamaecyparis lawsoniana	Port-Orford-cedar
Cinnamomum camphora	camphor-tree
Cryptomeria japonica	sugi
Eucalyptus botryoides	bangalay eucalyptus
Eucalyptus citriodora	lemon-gum eucalyptus
Eucalyptus paniculata	gray ironbark eucalyptus
Eucalyptus pilularis	blackbutt eucalyptus
Eucalyptus resinifera	kinogum eucalyptus

Eucalyptus robusta	robusta eucalyptus
Eucalyptus saligna	saligna eucalyptus
Eucalyptus sideroxylon	red-ironbark eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Fraxinus uhdei	tropical ash
Grevillea robusta	silk-oak
Pinus patula	jelecote pine
Pinus pinaster	cluster pine
Pinus radiata	Monterey pine
Sequoia sempervirens	redwood
Thuja plicata	western redcedar
Toona ciliata var. *australis*	Australian toon
Tristania conferta	brushbox

Other frequently planted commercial species not tallied in plots:

Scientific Name	*Common Name*
Acacia melanoxylon	blackwood acacia
Cedrela odorata	Spanish-cedar
Eucalyptus deglupta	bagras eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Pinus elliottii	slash pine
Swietenia macrophylla	Honduras mahogany
Syncarpia glomulifera	turpentine-tree

Noncommercial tree species: Tree species not now considered suitable for industrial products. The following were tallied on plots:

Scientific Name	*Common Name*
Acacia confusa	Formosa koa
Acacia decurrens	black-wattle acacia
Aleurites moluccana	kukui
Casuarina spp.	ironwood
Cheirodendron spp.	olapa
Cupressus macrocarpa	Monterey cypress
Cupressus spp.	cypress
Eucalyptus globulus	bluegum eucalyptus
Eucalyptus spp.	unidentified eucalyptus
Ficus spp.	fig
Melaleuca leucadendron	paper-bark
Melia azedarach	pride-of-India
Sophora chrysophylla	mamani

Other frequently planted noncommercial tree species not tallied on plots:

Scientific Name	*Common Name*
Eugenia cumini	Java-plum

Eucalyptus spp.	unidentified eucalyptus
Juniperus spp.	juniper
Spathodea campanulata	African tuliptree

Hardwoods: Dicotyledonous trees; usually broadleaved.

Conifers: Coniferous trees; usually evergreen, having needle or scale-like leaves. Also generally known as softwoods.

Forest types: Forests which are predominantly of a single species and in which no other species makes up 25 percent or more of the stand, are designated by the single species such as robusta eucalyptus type, ohia type, or tropical ash type. Otherwise, or for grouping of area statistics, they are designated:

Eucalyptus: Planted stands predominantly of eucalyptus species.

Hardwood: Planted stands predominantly of hardwoods other than the eucalypts.

Conifer: Planted forests predominantly of conifers.

Class of Timber

Growing stock: Live trees of good form and vigor and of species suited for industrial wood (commercial species).

Sawtimber trees: Live trees of commercial species of at least 11 inches diameter breast height which contain a butt half-log or a log which meets the specifications of standard lumber, or tie and timber log grades.

Poletimber trees: Live trees of commercial species between 5 and 10.9 inches d.b.h., having soundness and form necessary to develop into sawtimber trees.

Saplings and seedlings: Live trees of commercial species between 1 and 4.9 inches d.b.h. and less than 1 inch, respectively, which show promise of becoming sawtimber trees.

Sound cull trees: Live trees 1 inch d.b.h. or larger which do not qualify as growing stock because of species (noncommercial species), poor form, or excessive limbs.

Rotten cull trees: Live trees 1 inch d.b.h. or larger which are not growing stock or sound cull because of excessive rot.

Volume

International 1/4-inch kerf log rule: A formula rule for estimating the board-foot volume of logs, by 4-foot log sections; V equals 0.905 ($0.22D^2$ - 0.71D).

Sawtimber volume: The net volume of the sawlog portion of sawtimber trees, in board feet (International 1/4-inch rule).

Saw-log portion: That part of the main bole of sawtimber trees between the stump and the merchantable top.

Merchantable top: The point on the bole above which a merchantable saw log cannot be obtained; i.e., the point where the main stem divides into limbs or is less than 8 inches diameter inside bark.

Growing stock volume: Volume in cubic feet of sound wood in the bole of sawtimber and poletimber trees from stump to a minimum top diameter inside bark (d.i.b.) of 4 inches, or to the point where the main stem divides into limbs.

All timber volume: Volume in cubic feet of sound wood in the bole of growing stock and cull trees 5 inches d.b.h. or larger, from a stump to a minimum top diameter inside bark (d.i.b.) of 4 inches.

Stand-Size Classes

Sawtimber stands: Stands at least 10 percent stocked with growing-stock trees, half or more in sawtimber and poletimber trees, and sawtimber stocking at least equal to poletimber.

Poletimber stands: Stands failing to qualify as sawtimber but at least 10 percent stocked with growing-stock trees, at least half poletimber.

Sapling and seedling stands: Stands not qualifying as sawtimber or poletimber, but at least 10 percent stocked with growing-stock trees.

Nonstocked area: Commercial forest lands less than 10 percent stocked with growing-stock trees.

Miscellaneous

Diameter breast height (d.b.h.): Tree diameter in inches, outside bark, measured at 4-1/2 feet above the ground for normal trees, and 18 inches above the stilt or swell for abnormal trees.

Industrial wood: Commercial roundwood products, such as saw logs, veneer logs, and pulpwood. Fuelwood and fence posts are excluded.

Log grades: A classification of logs based on external characteristics as indicators of quality or value of lumber the logs will yield. Grade 1 is the highest quality, grade 2 intermediate, and grade 3 the lowest quality of standard hardwood factory lumber logs.[6] Grade 4 logs are suitable for ties and timbers.

Timber quality: Based on log grades unless stated otherwise. Characteristics of wood such as density, strength, color, and shrinkage, are also measures of quality. However, they are usually inherent in a species.

Inventory Procedure

Area and volume statistics presented in this report were developed plantation stand by plantation stand. First, individual forest plantations of 2 acres or more were identified and delineated on aerial photographs through stereoscopic study. Each plantation was given a stand number and classified as to type and stand-size group. The area of each plantation was measured from the photograph. Ownership and stand age were determined from maps and other records. Field examination of each plantation allowed for correcting delineations, classifications, and acreages.

Next, timber-volume plots were located on the ground in each commercial forest plantation of 5 acres and larger having sawtimber trees. The sample plot locations were selected at random from a grid of points overlaid on the aerial photograph. Two or more sample locations, depending on stand acreage and variability, were selected in each stand. At each location, tree measurements were made from which timber volume and quality could be computed and expanded. Detailed measurements were made on a "main" plot at each location, supplemented by additional but less detailed data on two "satellite" plots. All plots were variable plots with a basal area factor of 20.

Finally, the data were processed through a specially prepared computer program. Tree measurements were converted to volume units on a per-acre basis, averaged for the plots in a stand, and expanded for the acreage of the stand. The computer output consisted of tabular data for each stand and summaries of stand data by forest reserves.

Volumetric data for stands 2 to 4 acres in size were extrapolated from closely similar measured stands and added to the computer processed data.

---

[6] U.S. Forest Products Laboratory. *Hardwood log grades for standard lumber--proposals and results.* U.S. Forest Serv. Forest Prod. Lab. Rpt. 1737, 15 p., illus. 1953.

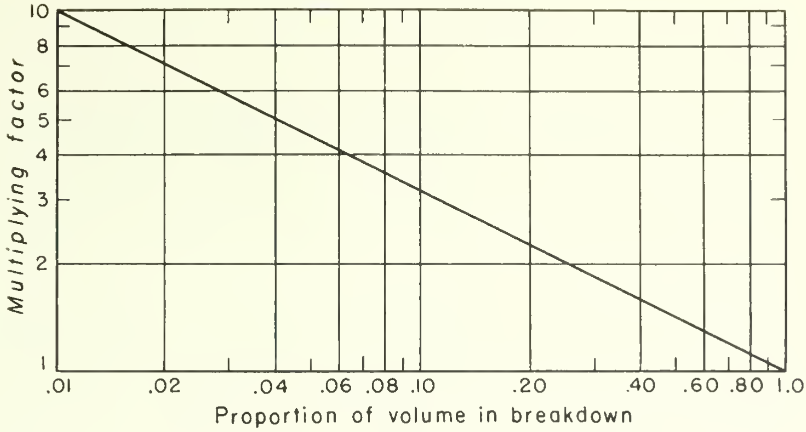


Figure 5.--Adjustment of sampling error for volume breakdown.

The accuracy goal for this inventory was ± 20 percent per 5 million net board feet of sawtimber in a stand, at the level of one standard error. The reliability of estimates for each forest reserve, based on measured stands only, are shown below. Two chances out of three the estimated volume does not vary from the actual by greater than the sampling error indicated (fig. 5).

Forest Reserve	*Total volume* (MBF)	*Sampling error* (percent)
Koolau	63,650	5.0
Kula	7,457	14.9
West Maui	537	26.3
Outside Forest Reserve	19,198	4.5

Table 1.—*Area of forest plantations by forest reserve and forest type, Island of Maui, 1967*

Forest reserve	Commercial forest types			Total commercial types	Total noncommercial types	Total all types
	Eucalyptus 1/	Hardwoods 2/	Conifers			
	Acres					
Koolau	2,194	7	35	2,236	2,257	4,493
Kula	42	89	1,137	1,268	293	1,561
Makawao	172	306	5	483	96	579
Waihou Spring	--	20	12	32	5	37
West Maui	34	--	43	77	52	129
Outside reserve	1,023	70	874	1,967	1,361	3,328
Total	3,465	492	2,106	6,063	4,064	10,127

1/ Includes turpentine-tree and brushbox.
2/ Except eucalypts.

Table 2.—*Area of forest plantation by forest reserve, ownership class,*[1] *and forest type, Island of Maui, 1967*

Forest reserve and ownership class	Commercial forest type			Total commercial types	Total noncommercial types	Total all types
	Eucalyptus 2/	Hardwoods	Conifers			
			Acres			
State: 3/						
Koolau	952	5	--	957	1,671	2,628
Kula	42	89	1,137	1,268	282	1,550
Makawao	172	306	5	483	96	579
Waihou Spring	--	20	12	32	5	37
West Maui	13	--	22	35	15	50
Outside reserve 3/	11	--	6	17	219	236
Total	1,190	420	1,182	2,792	2,288	5,080
Private:						
Koolau	1,242	2	35	1,279	586	1,865
Kula	--	--	--	--	11	11
West Maui	21	--	21	42	37	79
Outside reserve	1,012	70	868	1,950	1,142	3,092
Total	2,275	72	924	3,271	1,776	5,047
Island total	3,465	492	2,106	6,063	4,064	10,127

1/ Ownership of plantation stands is based on interpretation of locations on Tax-Key maps and topographic maps which are often inadequate for precise determinations. Therefore, for a given plantation stand, the ownership designation may be in error, although over-all ownership statistics are probably not greatly affected by this kind of error.

2/ Includes turpentine-tree and brushbox.

3/ Includes 4 acres of noncommercial types in other public (federal) ownership.

Table 3.—*Area of forest plantations by forest type, stand size class, and ownership class, Island of Maui, 1967*

Forest type and stand-size class	Ownership class		All ownerships
	State	Private	
	Acres		
Commercial types:			
Sawtimber stands			
Robusta eucalyptus	306	1,561	1,867
Other eucalyptus	100	660	760
Tropical ash	84	--	84
Other hardwoods	54	32	86
Norfolk-Island-pine	--	85	85
Redwood	243	35	278
Sugi	29	35	64
Other conifers	114	61	175
Total	930	2,469	3,399
Poletimber stands			
Eucalyptus[1]	--	51	51
Other hardwoods	5	40	45
Sugi	74	202	276
Conifers	2	506	508
Total	81	799	880
Seedling & sapling stands			
Saligna eucalyptus	780	--	780
Other eucalyptus	4	3	7
Tropical ash	155	--	155
Other hardwoods	122	--	122
Pines	665	--	665
Other conifers	55	--	55
Total	1,781	3	1,784
Total commercial	2,792	3,271	6,063
Noncommercial types:			
Bluegum eucalyptus	333	1,001	1,334
Other eucalyptus	21	132	153
Paper-bark	1,665	288	1,953
Ironwood	--	328	328
Other hardwoods	5	--	5
Cypress	256	27	283
Other conifers[2]	8	--	8
Total noncommercial	2,288	1,776	4,064
Total forest plantation	5,080	5,047	10,127

1/ Includes turpentine-tree and brushbox.

2/ Includes 4 acres of noncommercial type in other public ownership.

Table 4.—*Area of forest plantations by forest type and period of planting, Island of Maui, 1967*

Forest type	Period of planting									Total
	1876-1885	1886-1895	1896-1905	1906-1915	1916-1925	1926-1935	1936-1945	1946-1955	1956-1967	
	Acres									
Commercial types:										
Robusta eucalyptus	--	--	130	825	472	69	385	--	--	1,881
Saligna eucalyptus	--	--	--	--	--	--	--	--	780	780
Other eucalyptus 1/	80	36	270	145	7	152	107	--	7	804
Tropical ash	--	--	--	--	--	37	47	--	155	239
Australian toon	--	--	--	--	--	--	--	--	34	34
Other hardwoods	--	--	--	2	25	34	70	--	88	219
Norfolk-Island-pine	--	--	--	11	2	72	--	3	24	112
Redwood	--	--	--	--	--	106	172	--	28	306
Sugi	--	--	--	35	--	212	93	--	--	340
Other conifers	--	--	--	--	--	47	110	526	665	1,348
Total commercial	80	36	400	1,018	506	729	984	529	1,781	6,063
Noncommercial types:										
Bluegum eucalyptus	--	--	67	1,101	114	12	29	11	--	1,334
Other eucalyptus	--	--	--	27	41	74	11	--	--	153
Paper-bark	--	--	--	--	--	3	1,950	--	--	1,953
Ironwood	--	--	--	6	273	37	12	--	--	328
Other hardwoods	--	--	--	--	--	5	--	--	--	5
Conifers	4	--	6	8	--	12	261	--	--	291
Total noncommercial	4	--	73	1,142	428	143	2,263	11	--	4,064
Island total	84	36	473	2,160	934	872	3,247	540	1,781	10,127

1/ Includes turpentine-tree and brushbox.

Table 5.—*Volume of growing stock and sawtimber in planted sawtimber stands by species and stand acreage, Island of Maui, 1967*

(in thousands of feet)

Species	Stands 2 to 4 acres in size		Stands 5 acres and larger		All stands	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu.ft.	*Bd.ft.* 1/	*Cu.ft.*	*Bd.ft.* 1/	*Cu.ft.*	*Bd.ft.* 1/
Robusta eucalyptus	189	878	13,250	71,852	13,439	72,730
Bangalay eucalyptus	--	--	284	1,460	284	1,460
Blackbutt eucalyptus	--	--	31	195	31	195
Gray ironbark eucalyptus	7	35	101	562	108	597
Kinogum eucalyptus	4	16	66	308	70	324
Red-ironbark eucalyptus	--	--	26	115	26	115
Other eucalypts 2/	153	625	1,435	6,053	1,588	6,678
Hardwoods 3/	33	128	416	1,360	449	1,488
Redwood	37	183	1,240	6,040	1,277	6,223
Norfolk-Island-pine 4/	29	90	504	2,844	533	2,934
Sugi	46	176	257	854	303	1,030
Other conifers 5/	44	177	94	296	138	473
Total	542	2,308	17,704	91,939	18,246	94,247

1/ International 1/4-inch rule.
2/ Includes turpentine-tree and brushbox.
3/ Australian toon, camphor-tree, koa, mahogany, Molucca albizzia, silk-oak, teak, and tropical ash.
4/ Includes hoop-pine.
5/ Cluster pine, jelecote pine, Monterey pine, Port-Orford-cedar, and western redcedar.

Table 6.—*Volume of growing stock and sawtimber in planted sawtimber stands 5 acres and larger, by ownership class*[1] *and species, Island of Maui, 1967*

(in thousands of feet)

Species	State		Private		Total	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu.ft.	*Bd.ft.*[2/]	*Cu.ft.*	*Bd.ft.*[2/]	*cu.ft.*	*Bd.ft.*[2/]
Robusta eucalyptus	1,111	5,857	12,139	65,995	13,250	71,852
Bangalay eucalyptus	--	--	284	1,460	284	1,460
Blackbutt eucalyptus	--	--	31	195	31	195
Gray ironbark eucalyptus	--	--	101	562	101	562
Kinogum eucalyptus	--	--	66	308	66	308
Red-ironbark eucalyptus	--	--	26	115	26	115
Other eucalypts[3/]	68	263	1,367	5,790	1,435	6,053
Hardwoods[4/]	308	876	108	484	416	1,360
Redwood	1,180	5,790	60	250	1,240	6,040
Norfolk-Island-pine[5/]	--	--	504	2,844	504	2,844
Sugi	139	505	118	349	257	854
Other conifers[6/]	55	188	39	108	94	296
Total	2,861	13,479	14,843	78,460	17,704	91,939

1/ See footnote 1, Table 2.
2/ International 1/4-inch rule.
3/ Includes brushbox
4/ Australian toon, camphor-tree, koa, Molucca albizzia, silk-oak, and tropical ash.
5/ Includes hoop-pine.
6/ Cluster pine, jelecote pine, Monterey pine, Port-Orford-cedar, and western redcedar.

Table 7.—*Volume of growing stock and sawtimber in planted sawtimber stands 2 to 4 acres in size, by ownership class and species, Island of Maui, 1967*

(in thousands of feet)

Species	State		Private		Total	
	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber
	Cu.ft.	*Bd.ft.*1/	*Cu.ft.*	*Bd.ft.*1/	*Cu.ft.*	*Bd.ft.*1/
Robusta eucalyptus	145	702	44	176	189	878
Gray ironbark eucalyptus	--	--	7	35	7	35
Kinogum eucalyptus	--	--	4	16	4	16
Other eucalyptus2/	71	268	82	357	153	625
Other hardwoods3/	13	30	20	98	33	128
Redwood	37	183	--	--	37	183
Norfolk-Island-pine	--	--	29	90	29	90
Sugi	23	115	23	61	46	176
Other conifers4/	44	177	--	--	44	177
Total	333	1,475	209	833	542	2,308

1/ International 1/4-inch rule.
2/ Includes turpentine-tree and brushbox.
3/ Mahogany, silk-oak, teak, and tropical ash.
4/ Cluster pine and Port-Orford-cedar.

Table 8.—*Volume of sawtimber and growing stock in planted sawtimber stands 5 acres and larger, by species and diameter class, Island of Maui, 1967*

Species	All classes	Tree diameter class (inches at breast height) 5.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-28.9	29.0-38.9	39.0 plus
				Sawtimber in thousand board feet[1]					
Robusta eucalyptus	71,852	--	1,661	3,209	5,290	6,989	40,732	12,414	1,557
Bangalay eucalyptus	1,460	--	24	37	45	96	854	357	47
Other eucalypts[2]	7,233	--	359	583	617	846	2,941	1,204	683
Hardwoods[3]	1,360	--	90	243	191	223	395	175	43
Redwood	6,040	--	149	308	543	773	3,469	777	21
Norfolk-Island-pine[4]	2,844	--	22	129	474	812	1,407	--	--
Other conifers[5]	1,150	--	159	219	251	201	301	19	--
Total	91,939	--	2,464	4,728	7,411	9,940	50,099	14,946	2,351
				Growing stock in thousand cubic feet					
Robusta eucalyptus	13,250	258	622	821	1,095	1,306	6,932	1,990	226
Bangalay eucalyptus	284	5	10	9	10	19	157	66	8
Other eucalypts[2]	1,659	88	171	176	149	184	562	211	118
Hardwoods[3]	416	81	47	69	50	50	77	32	10
Redwood	1,240	60	91	81	111	145	613	135	4
Norfolk-Island-pine[4]	504	2	7	27	87	141	240	--	--
Other conifers[5]	351	75	62	59	55	40	56	4	--
Total	17,704	569	1,010	1,242	1,557	1,885	8,637	2,438	366

1/ International 1/4-inch rule.
2/ Includes brushbox.
3/ Australian toon, camphor-tree, koa, Molucca albizzia, silk-oak, and tropical ash.
4/ Includes hoop-pine.
5/ Cluster pine, jelecote pine, Monterey pine, Port-Orford cedar, sugi, and western redcedar.

Table 9.—*Volume of cull trees in planted sawtimber stands 5 acres and larger by species and forest reserve, Island of Maui, 1967*

Species	Forest reserve				Total
	Koolau	Kula	West Maui	Outside reserve	
	Thousand cubic feet				
Robusta eucalyptus	264	2	--	53	319
Other eucalypts	183	2	4	73	262
Other hardwoods1/	203	41	--	6	250
Conifers2/	2	40	--	13	55
Total	652	85	4	145	886

1/ Australian toon, black-wattle acacia, fig, Formosa koa, koa, kukui, mamani, Molucca albizzia, olapa, paper-bark, pride-of-India, and tropical ash.

2/ Includes cypress, ironwood, jelecote pine, western red-cedar, redwood, and sugi.

Table 10.—*Sawtimber volume in planted sawtimber stands 5 acres and larger by ownership class, species, and log grade,*[1] *Island of Maui, 1967*

Ownership class and species	All grades	Factory lumber logs			Tie and timber logs	Softwood species 2/
		Grade 1	Grade 2	Grade 3	Grade 4	
	Thousand board feet 3/					
State:						
Robusta eucalyptus	5,857	1,435	661	859	2,902	--
Other eucalypts 4/	262	11	12	24	215	--
Hardwoods 5/	877	--	--	51	826	--
Commercial conifers 6/	6,483	--	--	--	--	6,483
Total	13,479	1,446	673	934	3,943	6,483
Private:						
Robusta eucalyptus	65,995	16,210	8,072	9,573	32,140	--
Bangalay eucalyptus	1,460	388	243	235	594	--
Blackbutt eucalyptus	195	41	16	28	110	--
Gray ironbark eucalyptus	562	134	53	89	286	--
Kinogum eucalyptus	308	14	24	39	231	--
Red-ironbark eucalyptus	115	16	13	19	67	--
Other eucalypts 4/	5,790	371	417	850	4,152	--
Other hardwoods 5/	484	138	10	144	192	--
Commercial conifers 7/	3,551	--	--	--	--	3,551
Total	78,460	17,312	8,848	10,977	37,772	3,551
All ownerships:						
Robusta eucalyptus	71,852	17,640	8,733	10,432	35,042	--
Bangalay eucalyptus	1,460	388	243	235	594	--
Blackbutt eucalyptus	195	41	16	28	110	--
Gray ironbark eucalyptus	562	134	53	89	286	--
Kinogum eucalyptus	308	14	24	39	231	--
Red-ironbark eucalyptus	115	16	13	19	67	--
Other eucalypts 4/	6,052	382	429	874	4,367	--
Other hardwoods 5/	1,361	138	10	195	1,018	--
Commercial conifers	10,034	--	--	--	--	10,034
Total	91,939	18,758	9,521	11,911	41,715	10,034

1/ Based on standard specifications for hardwood log grades for standard lumber.

2/ Commercial conifer species are not log graded.

3/ International 1/4-inch rule.

4/ Includes brushbox.

5/ Includes Australian toon, camphor-tree, koa, Molucca albizzia, silk-oak, and tropical ash.

6/ Mainly redwood but includes sugi, cluster pine, jelecote pine, Monterey pine, Port-Orford-cedar, and western redcedar.

7/ Mainly Norfolk-Island-pine but includes redwood, sugi, and Port-Orford-cedar.

Table 11.—*Listing of individual stands and plantings with forest type, ownership, area, and volume Island of Maui, 1967*

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
				MBF
6001	Eucalyptus	Private	5	(1/)
6002	Eucalyptus	Private	16	161
6003	Eucalyptus	Private	21	120
6004	Eucalyptus	Private	15	181
6005	Eucalyptus	Private	17	148
6006	Eucalyptus	Private	4	33
6007	Eucalyptus	Private	13	107
6008	Ironwood	Private	4	(1/)
6009	Honduras mahogany	Private	2	34
6010	Norfolk-Island-pine	Private	5	165
6011	Eucalyptus	Private	8	26
6012	Eucalyptus	Private	3	25
6013	Eucalyptus	Private	5	26
6014	Eucalyptus	Private	10	96
6015	Eucalyptus	Private	2	10
6016	Juniper	Private	24	(2/)
6017	Norfolk-Island-pine	Private	14	295
6018	Sugi	Private	82	(2/)
6019	Norfolk-Island-pine	Private	41	1,554
6020	Sugi	Private	38	(2/)
6021	Ironwood	Private	22	(1/)
6022	Ironwood	Private	73	(1/)
6023	Robusta eucalyptus	Private	79	358
6024	Ironwood	Private	12	(1/)
6025	Ironwood	Private	13	(1/)
6026	Eucalyptus	Private	7	(1/)
6027	Robusta eucalyptus	Private	17	23
6028	Robusta eucalyptus	Private	26	25
6029	Eucalyptus	Private	8	(2/)
6030	Eucalyptus	Private	15	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6031	Robusta eucalyptus	Private	12	65
6032	Ironwood	Private	33	(1/)
6033	Robusta eucalyptus	Private	12	234
6034	Eucalyptus	Private	7	93
6035	Eucalyptus	Private	8	74
6036	Eucalyptus	Private	20	215
6037	Eucalyptus	Private	13	110
6038	Eucalyptus	Private	8	112
6039	Bluegum eucalyptus	Private	24	(1/)
6040	Bluegum eucalyptus	Private	11	(1/)
6041	Bluegum eucalyptus	Private	12	(1/)
6042	Silk-oak	Private	16	(2/)
6043	Eucalyptus	Private	6	22
6044	Eucalyptus	Private	38	369
6045	Bangalay eucalyptus	Private	16	613
6046	Eucalyptus	Private	4	37
6047	Bluegum eucalyptus	Private	3	(1/)
6048	Bluegum eucalyptus	Private	3	(1/)
6049	Bluegum eucalyptus	Private	6	(1/)
6050	Bluegum eucalyptus	Private	3	(1/)
6051	Bluegum eucalyptus	Private	12	(1/)
6052	Bluegum eucalyptus	Private	17	(1/)
6053	Bluegum eucalyptus	Private	80	(1/)
6054	Pines	State	4	7
6055	Cluster pine	State	2	3
6056	Bluegum eucalyptus	Private	9	(1/)
6057	Bluegum eucalyptus	Private	42	(1/)
6058	Bluegum eucalyptus	Private	8	(1/)
6059	Eucalyptus	State	4	14
6060	Pines	State	2	24

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6061	Bluegum eucalyptus	Private	7	(1/)
6062	Bluegum eucalyptus	Private	9	(1/)
6063	Bluegum eucalyptus	Private	8	(1/)
6064	Bluegum eucalyptus	Private	10	(1/)
6065	Bluegum eucalyptus	Private	9	(1/)
6066	Eucalyptus	Private	43	1,087
6067	Cypress	Private	4	(1/)
6068	Eucalyptus	Private	18	315
6069	Eucalyptus	Private	11	39
6070	Eucalyptus	Private	2	7
6071	Bluegum eucalyptus	Private	2	(1/)
6072	Bluegum eucalyptus	Private	8	(1/)
6073	Bluegum eucalyptus	Private	16	(1/)
6074	Bluegum eucalyptus	Private	6	(1/)
6075	Bluegum eucalyptus	Private	65	(1/)
6076	Bangalay eucalyptus	Private	29	333
6077	Bangalay eucalyptus	Private	17	230
6078	Eucalyptus	Private	7	126
6079	Eucalyptus	Private	2	36
6080	Monterey cypress	Private	6	(1/)
6081	Conifers	Private	120	(2/)
6082	Redwood	Private	35	250
6083	Monterey cypress	Private	5	(1/)
6084	Conifers	Other public	4	(1/)
6085	Eucalyptus	Private	15	(1/)
6086	Bluegum eucalyptus	Private	8	(1/)
6087	Bluegum eucalyptus	Private	11	(1/)
6088	Eucalyptus	Private	12	251
6089	Bluegum eucalyptus	Private	17	(1/)
6090	Bluegum eucalyptus	State	8	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6091	Bluegum eucalyptus	Private	5	(1/)
6092	Bluegum eucalyptus	Private	12	(1/)
6093	Bluegum eucalyptus	State	44	(1/)
6094	Bluegum eucalyptus	State	36	(1/)
6095	Bluegum eucalyptus	State	27	(1/)
6096	Bluegum eucalyptus	State	23	(1/)
6097	Bluegum eucalyptus	State	21	(1/)
6098	Bluegum eucalyptus	Private	11	(1/)
6099	Eucalyptus	Private	30	331
6100	Eucalyptus	Private	45	719
6101	Eucalyptus	State	6	(1/)
6102	Robusta eucalyptus	State	4	58
6103	Hardwoods & conifers	State	34	(3/)
6104	Paper-bark	State	9	(1/)
6105	Eucalyptus	State	4	37
6106	Paper-bark	State	90	(1/)
6107	Norfolk-Island-pine	Private	11	834
6108	Ironwood	Private	6	(1/)
6109	Eucalyptus	Private	50	517
6110	Bluegum eucalyptus	Private	3	(1/)
6111	Robusta eucalyptus	Private	88	5,476
6112	Robusta eucalyptus	Private	5	169
6113	Bluegum eucalyptus	Private	103	(1/)
6114	Robusta eucalyptus	Private	96	6,639
6115	Robusta eucalyptus	Private	34	1,743
6116	Robusta eucalyptus	Private	108	7,178
6117	Sugi	Private	3	19
6118	Robusta eucalyptus	Private	94	7,289
6119	Paper-bark	State	13	(1/)
6120	Paper-bark	Private	42	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6121	Robusta eucalyptus	State	70	733
6122	Paper-bark	Private	25	(1/)
6123	Robusta eucalyptus	State	4	76
6124	Robusta eucalyptus	Private	15	219
6125	Paper-bark	State	39	(1/)
6126	Paper-bark	State	71	(1/)
6127	Eucalyptus	Private	21	144
6128	Robusta eucalyptus	State	4	76
6129	Robusta eucalyptus	State	36	483
6130	Robusta eucalyptus	Private	20	1,196
6131	Robusta eucalyptus	Private	30	912
6132	Robusta eucalyptus	Private	17	525
6133	Eucalyptus	Private	21	243
6134	Eucalyptus	Private	10	151
6135	Kinogum eucalyptus	Private	7	192
6136	Bluegum eucalyptus	Private	24	(1/)
6137	Bluegum eucalyptus	Private	10	(1/)
6138	Eucalyptus	Private	12	70
6139	Bluegum eucalyptus	Private	36	(1/)
6140	Bluegum eucalyptus	State	56	(1/)
6141	Brushbox	State	4	3
6142	Bluegum eucalyptus	State	88	(1/)
6143	Robusta eucalyptus	Private	25	1,235
6144	Eucalyptus	Private	12	(1/)
6145	Eucalyptus	State	7	153
6146	Robusta eucalyptus	Private	54	4,331
6147	Bluegum eucalyptus	Private	14	(1/)
6148	Bluegum eucalyptus	Private	18	(1/)
6149	Robusta eucalyptus	Private	10	107
6150	Robusta eucalyptus	State	4	58

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6151	Bluegum eucalyptus	Private	71	(1/)
6152	Robusta eucalyptus	Private	42	3,078
6153	Bluegum eucalyptus	State	8	(1/)
6154	Sugi	Private	3	41
6155	Robusta eucalyptus	Private	104	5,640
6156	Robusta eucalyptus	Private	27	678
6157	Robusta eucalyptus	Private	37	1,174
6158	Eucalyptus	State	20	(3/)
6159	Sugi	Private	12	165
6160	Sugi	Private	12	228
6161	Robusta eucalyptus	Private	49	2,615
6162	Robusta eucalyptus	Private	49	1,203
6163	Robusta eucalyptus	Private	104	2,089
6164	Robusta eucalyptus	Private	98	1,877
6165	Paper-bark	State	11	(1/)
6166	Paper-bark	State	10	(1/)
6167	Robusta eucalyptus	Private	54	2,194
6168	Robusta eucalyptus	State	17	415
6169	Robusta eucalyptus	State	21	574
6170	Robusta eucalyptus	State	13	232
6171	Paper-bark	State	34	(1/)
6172	Robusta eucalyptus	State	4	76
6173	Robusta eucalyptus	State	4	76
6174	Paper-bark	State	167	(1/)
6175	Robusta eucalyptus	State	4	76
6176	Paper-bark	State	17	(1/)
6177	Paper-bark	Private	5	(1/)
6178	Paper-bark	State	25	(1/)
6179	Paper-bark	State	17	(1/)
6180	Paper-bark	State	22	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6181	Robusta eucalyptus	Private	27	494
6182	Ironwood	Private	12	(1/)
6183	Robusta eucalyptus	Private	4	22
6184	Robusta eucalyptus	Private	4	22
6185	Robusta eucalyptus	State	4	58
6186	Paper-bark	State	38	(1/)
6187	Paper-bark	State	7	(1/)
6188	Paper-bark	State	12	(1/)
6189	Robusta eucalyptus	State	4	58
6190	Paper-bark	State	9	(1/)
6191	Paper-bark	State	33	(1/)
6192	Paper-bark	State	14	(1/)
6193	Robusta eucalyptus	Private	4	54
6194	Robusta eucalyptus	State	4	54
6195	Paper-bark	State	4	(1/)
6196	Paper-bark	State	105	(1/)
6197	Paper-bark	State	13	(1/)
6198	Paper-bark	State	23	(1/)
6199	Paper-bark	State	21	(1/)
6200	Robusta eucalyptus	State	17	1,097
6201	Robusta eucalyptus	State	17	980
6202	Paper-bark	State	54	(1/)
6203	Eucalyptus	Private	11	155
6204	Sugi	Private	36	(2/)
6205	Paper-bark	Private	15	(1/)
6206	Paper-bark	Private	15	(1/)
6207	Juniper	Private	15	(2/)
6208	Paper-bark	Private	81	(1/)
6209	Robusta eucalyptus	Private	12	182
6210	Eucalyptus	Private	7	85

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6211	Paper-bark	Private	69	(1/)
6212	Robusta eucalyptus	Private	30	330
6213	Robusta eucalyptus	State	22	417
6214	Bangalay eucalyptus	Private	11	261
6215	Robusta eucalyptus	Private	12	813
6216	Paper-bark	Private	10	(1/)
6217	Cypress	Private	2	(1/)
6218	Brushbox	State	4	3
6219	Robusta eucalyptus	Private	17	685
6220	Redwood	State	9	645
6221	Bluegum eucalyptus	Private	17	(1/)
6222	Bluegum eucalyptus	Private	195	(1/)
6223	Robusta eucalyptus	Private	74	4,963
6224	Sugi	Private	5	32
6225	Bluegum eucalyptus	Private	12	(1/)
6226	Bluegum eucalyptus	Private	9	(1/)
6227	Brushbox	Private	14	10
6228	Brushbox	Private	6	(2/)
6229	Robusta eucalyptus	Private	14	(2/)
6230	Brushbox	Private	4	(2/)
6231	Eucalyptus	Private	2	18
6232	Eucalyptus	Private	4	14
6233	Norfolk-Island-pine	Private	4	7
6234	Hardwoods & conifers	State	20	(3/)
6235	Redwood	State	23	235
6236	Hardwoods	State	5	(1/)
6237	Robusta eucalyptus	Private	4	58
6238	Eucalyptus	Private	3	(2/)
6239	Robusta eucalyptus	Private	20	299
6240	Paper-bark	Private	15	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6241	Paper-bark	State	6	(1/)
6242	Robusta eucalyptus	State	45	938
6243	Paper-bark	Private	8	(1/)
6244	Eucalyptus	Private	8	64
6245	Pines	Private	19	(2/)
6246	Pines	Private	60	(2/)
6247	Pines	Private	56	(2/)
6248	Conifers	Private	119	(2/)
6249	Pines	Private	8	(2/)
6250	Pines	Private	39	85
6251	Conifers	Private	70	(2/)
6252	Pines	Private	22	22
6253	Bluegum eucalyptus	Private	34	(1/)
6254	Bluegum eucalyptus	Private	3	(1/)
6255	Bluegum eucalyptus	Private	11	(1/)
6256	Redwood	State	29	434
6257	Monterey cypress	State	12	(1/)
6258	Sugi	State	48	(2/)
6259	Sugi	State	2	48
6260	Eucalyptus	State	34	109
6261	Mountain albizzia	State	5	(2/)
6262	Monterey cypress	State	27	(1/)
6263	Monterey cypress	State	19	(1/)
6264	Cluster pine	State	4	9
6265	Eucalyptus	State	4	23
6266	Bluegum eucalyptus	State	3	(1/)
6267	Bluegum eucalyptus	State	9	(1/)
6268	Bluegum eucalyptus	State	10	(1/)
6269	Eucalyptus	State	2	11
6270	Eucalyptus	State	2	11

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6271	Sugi	State	19	(2/)
6272	Sugi	State	7	(2/)
6273	Port-Orford-cedar	State	4	134
6274	Redwood	State	80	91
6275	Tropical ash	State	6	1
6276	Redwood	State	20	170
6277	Tropical ash	State	21	138
6278	Redwood	State	44	2,009
6279	Sugi	State	2	67
6280	Redwood	State	16	488
6281	Tropical ash	State	19	170
6282	Redwood	State	8	457
6283	Tropical ash	State	3	20
6284	Tropical ash	State	6	34
6285	Redwood	State	4	122
6286	Redwood	State	2	61
6287	Tropical ash	State	4	7
6288	Monterey cypress	State	73	(1/)
6289	Tropical ash	State	2	3
6290	Hardwoods & conifers	State	40	471
6291	Tropical ash	State	8	13
6292	Conifers	State	6	10
6293	Monterey cypress	State	125	(1/)
6294	Silk-oak	Private	7	(2/)
6295	Conifers	State	4	(1/)
6296	Sugi	State	5	81
6297	Sugi	State	7	129
6298	Sugi	State	5	12
6299	Hardwoods & conifers	State	23	468
6300	Redwood	State	17	702

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6301	Redwood	State	11	71
6302	Ironwood	Private	4	(1/)
6303	Eucalyptus	Private	9	(1/)
6304	Ironwood	Private	5	(1/)
6305	Eucalyptus	Private	6	(1/)
6306	Ironwood	Private	8	(1/)
6307	Ironwood	Private	13	(1/)
6308	Ironwood	Private	4	(1/)
6309	Eucalyptus	Private	6	(1/)
6310	Lemon-gum eucalyptus	Private	2	(2/)
6311	Ironwood	Private	6	(1/)
6312	Robusta eucalyptus	Private	29	195
6313	Ironwood	Private	14	(1/)
6314	Ironwood	Private	4	(1/)
6315	Molucca albizzia	Private	25	365
6316	Ironwood	Private	11	(1/)
6317	Robusta eucalyptus	Private	11	181
6318	Robusta eucalyptus	Private	9	15
6319	Ironwood	Private	5	(1/)
6320	Sugi	Private	33	(2/)
6321	Silk-oak	Private	5	(2/)
6322	Eucalyptus	Private	5	(1/)
6323	Ironwood	Private	9	(1/)
6324	Norfolk-Island-pine	Private	4	21
6325	Hardwoods	Private	3	52
6326	Paper-bark	Private	3	(1/)
6327	Norfolk-Island-pine	Private	2	42
6328	Ironwood	Private	2	(1/)
6329	Ironwood	Private	4	(1/)
6330	Ironwood	Private	5	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6331	Cypress	Private	4	(1/)
6332	Eucalyptus	Private	13	170
6333	Sugi	Private	3	(2/)
6334	Eucalyptus	Private	15	(1/)
6335	Silk-oak	Private	3	(2/)
6336	Eucalyptus	Private	12	(1/)
6337	Eucalyptus	Private	8	(1/)
6338	Eucalyptus	Private	8	(1/)
6339	Silk-oak	Private	6	(2/)
6340	Cypress	Private	6	(1/)
6341	Eucalyptus	Private	3	(1/)
6342	Eucalyptus	Private	3	25
6343	Hardwoods	Private	2	6
6344	Ironwood	Private	4	(1/)
6345	Eucalyptus	Private	6	73
6346	Kinogum eucalyptus	Private	2	16
6347	Silk-oak	Private	3	(2/)
6348	Brushbox	Private	14	(2/)
6349	Sugi	Private	3	(2/)
6350	Sugi	Private	4	(2/)
6351	Western redcedar	State	9	39
6352	Tropical ash	State	15	212
6353	Sugi	State	8	267
6354	Sugi	Private	3	(2/)
6355	Eucalyptus	Private	2	(1/)
6356	Norfolk-Island-pine	Private	2	10
6357	Eucalyptus	State	15	(1/)
6358	Eucalyptus	State	3	35
6359	Ironwood	Private	4	(1/)
6360	Ironwood	Private	10	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6361	Ironwood	Private	4	(1/)
6362	Ironwood	Private	4	(1/)
6363	Ironwood	Private	7	(1/)
6364	Ironwood	Private	3	(1/)
6365	Robusta eucalyptus	Private	3	20
6366	Ironwood	Private	5	(1/)
6367	Lemon-gum eucalyptus	Private	2	14
6368	Ironwood	Private	14	(1/)
6369	Ironwood	Private	4	(1/)
6370	Gray ironbark eucalyptus	Private	2	35
6371	Bluegum eucalyptus	Private	4	(1/)
6372	Brushbox	State	4	3
6373	Saligna eucalyptus	Private	2	132
6374	Silk-oak	Private	2	12
6375	Norfolk-Island-pine	Private	2	10
6376	Eucalyptus	Private	4	(1/)
6377	Port-Orford-cedar	Private	2	(2/)
6378	Pines	Private	13	(2/)
6379	Paper-bark	State	18	(1/)
6380	Paper-bark	State	20	(1/)
6381	Paper-bark	State	13	(1/)
6382	Eucalyptus	State	4	43
6383	Robusta eucalyptus	State	4	18
6384	Robusta eucalyptus	State	4	18
6385	Paper-bark	State	25	(1/)
6386	Eucalyptus	State	4	84
6387	Paper-bark	State	67	(1/)
6388	Paper-bark	State	160	(1/)
6389	Paper-bark	State	63	(1/)
6390	Paper-bark	State	194	(1/)

See footnotes at end of Table.

Table 11, continued

FORESTS PLANTED BEFORE 1950

Stand No.	Forest type	Owner	Acres	Total stand volume
6391	Paper-bark	State	121	(1/)
6392	Paper-bark	State	120	(1/)
6393	China-fir	State	2	(2/)
6394	Bluegum eucalyptus	Private	3	(1/)
	Total		8,343	94,247

See footnotes at end of Table.

Table 11, continued

AREAS REFORESTED 1950-67[4/]

Stand No.	Forest type	Owner	Acres	Total stand volume
	Koolau Forest Reserve:			
--	Australian toon	State	5	(2/)
--	Bagras eucalyptus	State	4	(2/)
--	Hardwoods	State	51	(2/)
--	Saligna eucalyptus	State	587	(2/)
	Total Koolau F. R.		647	--
	Kula Forest Reserve:			
--	Pines	State	622	(2/)
--	Monterey pine	State	33	(2/)
	Redwood	State	28	(2/)
	Total Kula F. R.		683	--
	Makawao Forest Reserve:			
--	Australian toon	State	29	(2/)
--	Koa[5/]	State	45	(2/)
--	Mountain albizzia	State	1	(2/)
--	Norfolk-Island-pine	State	5	(2/)
--	Saligna eucalyptus	State	98	(2/)
--	Hardwoods	State	76	(2/)
--	Tropical ash	State	155	(2/)
	Total Makawao F. R.		409	--

See footnotes at end of Table.

Table 11, continued

AREAS REFORESTED 1950-67[4/]

Stand No.	Forest type	Owner	Acres	Total stand volume
	Waihou Spring Forest Reserve:			
--	Pines	State	4	(2/)
	Total Waihou Spring F. R.		4	--
	West Maui Forest Reserve:			
--	Norfolk-Island-pine	State	22	(2/)
--	Saligna eucalyptus	State	10	(2/)
	Total West Maui F. R.		32	--
	Outside Forest Reserve:			
--	Loblolly pine[6/]	State	6	(2/)
--	Pines and bagras eucalyptus[7/]	Private	3	(2/)
	Total Outside F. R.		9	--
	Total		1,784	--
	Total forest plantations		10,127	94,247

1/ Noncommercial plantation type.
2/ Poletimber or seedling and sapling stands.
3/ No volume estimated-experimental planting.
4/ No stand numbers assigned.
5/ Natural regeneration.
6/ Experimental pine planting-Olinda.
7/ Baldwin planting-Puu Pane.

Table 12.—*Identity of individual plantation stands in the groups shown on the map "Forest Plantations on the Island of Maui, 1967"*[1]

Group stand No.	Individual stand number
1	6013-20; 6204, 07; 6320, 6345-46, 49-50
2	6001-8, 10-12; 6217; 6328-34, 36-43, 55
3	6009; 6294; 6321-27, 35, 47-48, 56
4	6025-26, 32-33; 6127, 33; 6311-19, 57-66
5	6021-24, 27-28, 31; 6302-10, 67-69
6	6056, 58, 65-70, 88, 98-99; 6100; 6203, 10; 6370
7	6029-30; 6107-09; 6226, 33, 37
8	6094-97; 6220, 35, 56-59, 61-93, 95-99; 6300-01, 51-53, 93
9	6110-13, 48; 6225; 6354, 94
10	6034-47; 6134-37, 39; 6214, 25, 27-32
11	6086-87, 89-93; 6253-54
12	6048-55, 57, 59-64, 71-74; 6234, 36; 6375
13	6075-79, 85
14	6114-18, 46-47, 49; 6224; 6371
15	6103, 41-45, 50-64, 67; 6215, 18-19, 21-23; 6372-74
16	6080-84; 6244-52; 6376-78
17	6101-02, 04-06, 19-22; 6238-43; 6379-81
18	6116, 23-26, 28-32, 65, 72-73, 75-77, 84-85, 90, 93-95; 6206, 08-09, 11-13
19	6166, 68-71, 74, 76, 79-80, 86-89, 91-92, 96-99; 6200-02, 05
20	6382-92
21	6181
22	6182-83

1/ Unnumbered stands on the map are identified by symbols as follows:

KORP--Koolau F.R. reforestation planting, 1960-67; includes seedling, sapling, and poletimber.
KRP --Kula F.R. reforestation planting, 1950-67; includes seedling, sapling, and poletimber.
MRP --Makawao F.R. reforestation planting, 1962-65; includes seedling, sapling, and poletimber.
WSRP--Waihou Spring F.R. reforestation planting, 1956-65; includes seedling, sapling, and poletimber.
WMRP--West Maui F.R. reforestation planting, 1950-62; includes seedling, sapling, and poletimber.

GPO 978-009

The Forest Service of the U.S. Department of Agriculture

. . . Conducts forest and range research at more than 75 locations from Puerto Rico to Alaska and Hawaii.

. . . Participates with all State forestry agencies in cooperative programs to protect and improve the Nation's 395 million acres of State, local, and private forest lands.

. . . Manages and protects the 187-million-acre National Forest System for sustained yield of its many products and services.

The Pacific Southwest Forest and Range Experiment Station

represents the research branch of the Forest Service in California and Hawaii.

GPO 978-009

PACIFIC SOUTHWEST
Forest and Range Experiment Station

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE P.O. BOX 245, BERKELEY, CALIFORNIA 94701

Soils and Vegetation of the FRENCH GULCH QUADRANGLE (24D-1,2,3,4)
Trinity and Shasta Counties, California

James I. Mallory Wilmer L. Colwell, Jr. W. Robert Powell

Published in cooperation
with the State of California:
The Resources Agency,
Department of Conservation,
Division of Forestry
University of California,
Division of
Agriculture Sciences

USDA FOREST SERVICE RESOURCE BULLETIN PSW-12 /1973

FOREWORD

Basic information about soils and vegetation—their characteristics, location, extent, and relationships—is especially useful to the land manager. It provides him with a foundation for understanding and managing the ecosystem—the ecological community that includes soils, vegetation, animals, and climate. And by applying an ecological approach, he can make more efficient and productive use of the land. He can apply management procedures that have proved successful in areas of known soils and vegetation to other areas with the same characteristics. With basic information on hand, the land manager lessens his chances of having an extension of these procedures turn out to be hit-or-miss propositions or—at worst—an outright failure.

Soil vegetation surveys are designed to produce useful maps and information. The data are useful to both the practitioner as well as the researcher. In land management research, prior knowledge of the ecosystem is mandatory if the work is to succeed. If the vegetation is to be changed, the information from such surveys might be used to estimate probable results.

The maps and the accompanying information in this report were prepared by the State Cooperative Soil-Vegetation Survey project of the Pacific Southwest Forest and Range Experiment Station, Forest Service. The project is financed through appropriations of the California Legislature to the Division of Forestry, Department of Conservation, Resources Agency of California. Cooperating organizations in the Soil-Vegetation Survey are the Division of Forestry; the Department of Agronomy and Range Science and Department of Soils and Plant Nutrition, University of California, Davis; School of Forestry and Conservation, University of California, Berkeley; and the Pacific Southwest Forest and Range Experiment Station at Berkeley. Project Leader is Wilmer L. Colwell, Jr., Pacific Southwest Forest and Range Experiment Station at Berkeley.

CONTENTS

The Authors

JAMES I. MALLORY is assigned to the Station's Cooperative Soil-Vegetation Survey as area leader, with headquarters in Redding, Calif. He earned a B.A. in wildlife conservation (1950) at the University of California, Berkeley, and joined the Station staff in 1954. **WILMER L. COLWELL, JR.** is research forester in charge of the Cooperative Soil-Vegetation Survey, headquartered at Berkeley. A 1938 forestry graduate of North Carolina State University, he also holds a M.S. degree (1950) from the University of California, Berkeley. He joined the Station in 1946. **W. ROBERT POWELL** is an Associate Specialist in the Department of Agronomy and Range Sciences, University of California, Davis. He earned a B.S. degree (1952) at the University of California, Berkeley, and joined the University staff in 1958.

ACKNOWLEDGMENTS

This survey of soils and vegetation in the area covered by the French Gulch Quadrangle used both intensive field investigations and aerial photo interpretation. Field work was done from 1961 to 1964 and in 1968. Analysis of data, cartography, and this report were completed in 1972.

We thank the following persons for their invaluable contributions to this work:

- Chester O. Stone, forester, California Division of Forestry, for aerial photo interpretation and soil and vegetation field mapping.
- Benjamin F. Smith, soil scientist, Pacific Southwest Forest and Range Experiment Station, for aerial photo interpretation and soil and vegetation field mapping.
- James M. Crawford, formerly research forester, Pacific Southwest Forest and Range Experiment Station, for aerial photo interpretation and soil and vegetation field mapping.
- Theodore A. Klaseen, soil scientist, Soil Conservation Service, for aerial photo interpretation and soil and vegetation field mapping.
- Earl B. Alexander, formerly soil scientist, Pacific Southwest Forest and Range Experiment Station, for aerial photo interpretation and soil and vegetation field mapping.

The French Gulch Quadrangle (U.S. Geological Survey 1944) includes 145,000 acres of mountainous land, mostly forested with some chaparral and woodland grass, located between 7 and 25 miles west of Redding *(fig. 1)*. Most of this acreage is in Shasta County with part of it in Trinity County in the Trinity range of the Klamath Mountains in northern California. The most prominent landmarks are Shasta Bally Mountain (6,209 feet elevation) and Whiskeytown Reservoir *(fig. 2)*. State Highway 299, between Redding, Shasta County and Weaverville, Trinity County, crosses the quadrangle. Shasta County Highway A-16 crosses the southeast corner through the village of Igo between Redding and Platina. A main county road leads north from Highway 299 to the old mining town of French Gulch, which lies along Clear Creek in the north.

The land is used mostly for watershed, but timber production, outdoor recreation, and wildlife habitat are also important. Livestock grazing is dominant in the southeast, near and west of Igo. Mining for copper, zinc, gold, sulfur, and other ores was formerly important in the vicinity of French Gulch and is still an obvious, if not active, part of the area. Most of the land is privately owned. Public Land is administered by the U.S. Bureau of Land Management, U.S. National Park Service, and U.S. Forest Service.

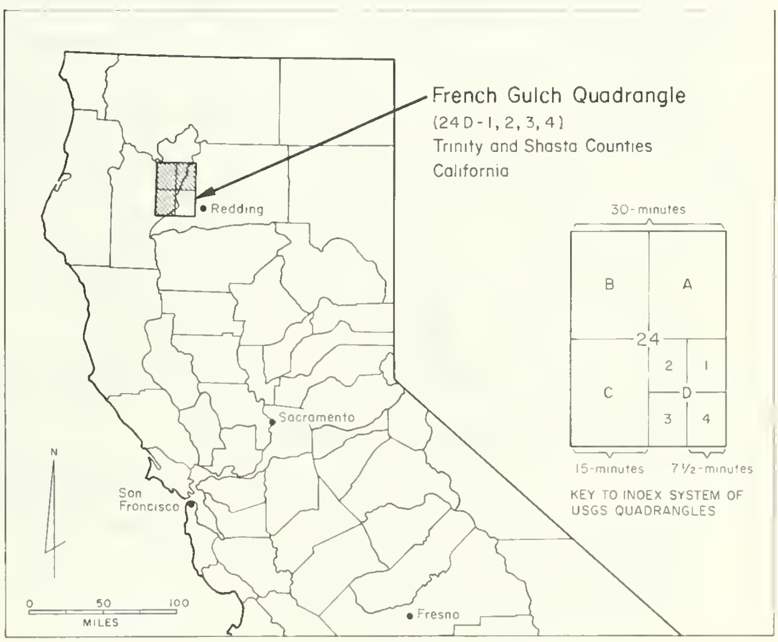


Figure 1—The French Gulch Quadrangle lies about 7 miles west of Redding, California.

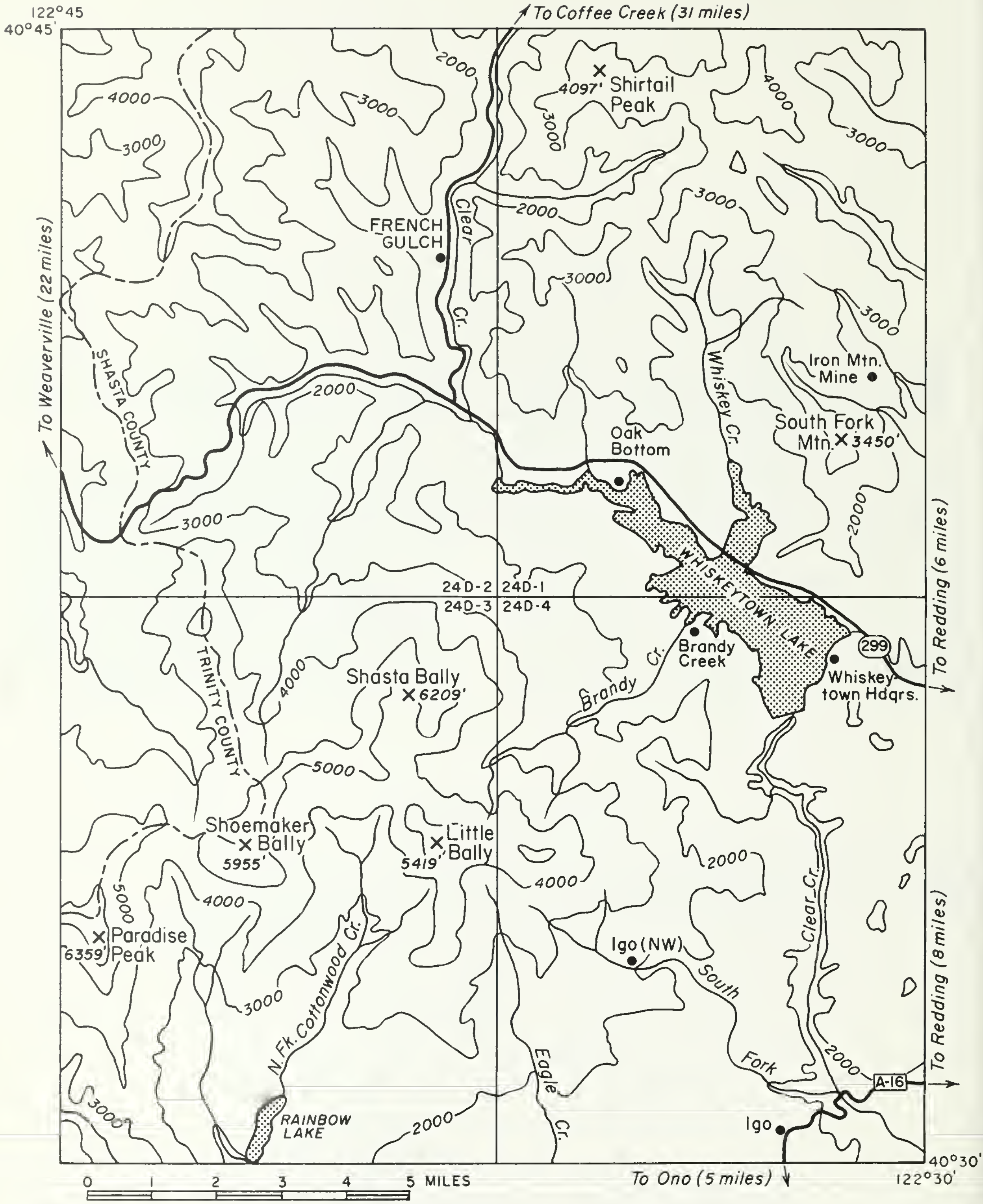


Figure 2—Topographic map of the French Gulch Quadrangle (U.S. Geological Survey 1964).

SURVEY AREA

Climate

The climate of the French Gulch area is hot and dry from late spring to mid-fall, when it turns cool with rain and snow falling intermittently. Below 2,000 feet elevation, snow seldom remains on the ground for more than 2 weeks; above 4,500 feet, a snowpack remains from December into April in most years. For example, on April 20, 1967, after a fairly normal winter, 8 feet of snow stood on the level ground and drifts were 20 feet deep at 6,200 feet elevation on Shasta Bally Mountain.[1]

The average annual precipitation *(fig. 3)* ranges from about 38 inches near Igo to more than 80 inches near Iron Mountain Mine (California Department of Water Resources 1964). Limited data[1] indicate wide variability in rainfall in short distances. For example, 24.8 inches were measured at Brandy Creek on the south shore of Whiskeytown Lake in January 1969. Only 13.9 inches were measured at Oak Bottom 2.5 miles to the northwest on the north shore of the Lake, and only 12.9 inches were measured at the summit of Shasta Bally Mountain 4.5 miles to the west and about 5,000 feet higher. Wide variability from season to season was demonstrated at Brandy Creek gauge, where 93 inches were measured in the 1966-67 season, 54 inches in the 1967-68 season, and 79 inches in the 1968-69 season. At French Gulch, the amount of rain was 43 inches in 1966-67; 26 inches in 1967-68; and 51 inches in 1968-69.

The average annual temperatures in the area range from 42°F. on Shasta Bally Mountain to 60°F. at National Park Service offices on the east shore of Whiskeytown Lake and a few degrees higher near Igo and on south-facing slopes below 2,000 feet elevation. The frost-free season varies from about 140 days in the higher elevations to about 250 days at most locations below 2,000 feet elevation (U.S. Weather Bureau 1965).

Geology

The French Gulch Quadrangle lies entirely within the Klamath Mountains geologic province (Bailey 1966). The geology has been described in detail by Albers (1964); Albers, *et al.* (1964); and Kinkel, *et al.* (1956). The varied rock types in this quadrangle can be placed in 10 groups *(fig. 4)*, seven of which are geologic formations ranging in age from pre-silurian to recent:

Abrams Mica Schist: The oldest rocks exposed in the Quadrangle are the Abrams schists in the southwest corner. Quartz-mica schists of probably pre-silurian age are extensive in the Weaverville Quadrangle to the west. Along the east edge of the schists is an intermittently exposed belt of serpentine and peridotite about one-fourth mile wide.

Shasta Bally Batholith: The next major formation to the east is the granitic Shasta Bally Batholith, which occupies more than one-third of the Quadrangle. The batholith is surrounded by a shell of gneissic rocks produced by contact metamorphism of the surrounding rocks at the time the granitic material was intruded.

Copley Greenstone: The Copley Greenstone of probable Devonian age lies in the west and north. It consists of massive basic and intermediate volcanic

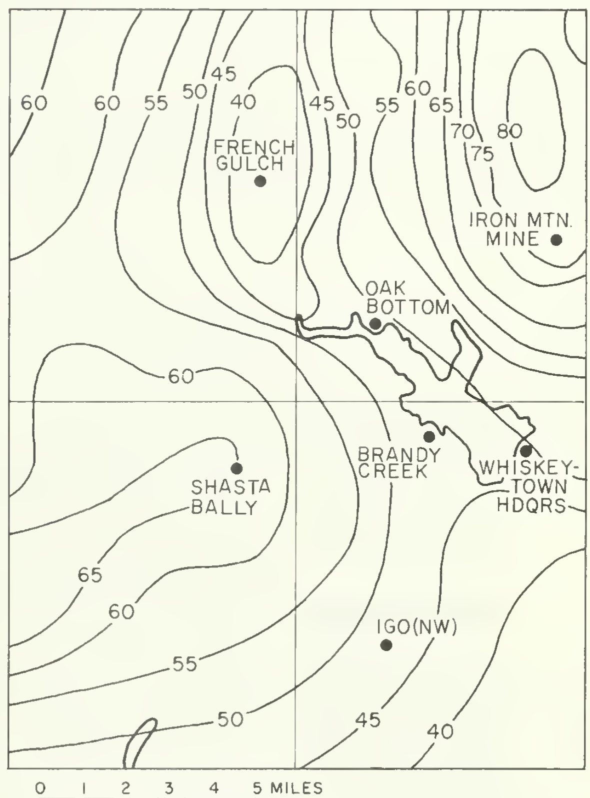


Figure 3—Isohyetal map shows distribution of equal mean seasonal precipitation (inches) in the French Gulch Quadrangle (California Department of Water Resources 1964). ● indicates rain gauge location.

[1]Data on file at U.S. National Park Service offices at Whiskeytown, California.

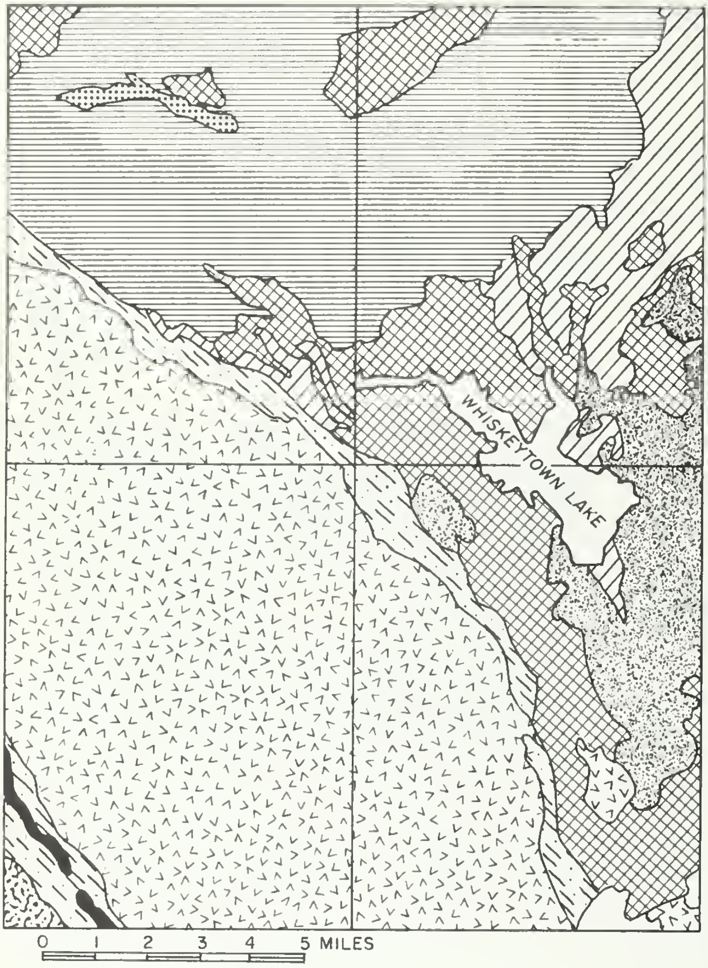


Figure 4—Geologic map shows rock types that are parent materials for the present soils. (Generalized from Albers, *et al.* 1964)

Rock Types	*Formation*	*Epoch*
Semi consolidated gravels	Red Bluff	Quaternary (Pleistocene)
Birdseye porphyry	--	Jurassic or Cretaceous
Quartz diorite and granodiorite	Shasta Bally Batholith	
Gneiss and amphibolite	--	
Peridotite and serpentine	--	
Trondhjemite and albite granite	Mule Mountain Stock	
Shale and conglomerate	Bragdon	Mississipian
Meta-rhyolite	Balaklala Rhyolite	Devonian
Meta-andesite	Copley Greenstone	
Mica schist	Abrams Mica Schist	Pre-Silurian

rocks that have been hydrothermally altered to greenstone. Where the greenstone adjoins the Shasta Bally Batholith it has undergone contact metamorphism to gneiss and schist.

Balaklala Rhyolite: North and east of Whiskeytown Lake the Balaklala Rhyolite overlies the Copley Greenstone. In Devonian time it erupted on top of the Copley Greenstone with some interfingering. The Balaklala Rhyolite is light colored, massive to porphyritic, and is the host rock for the massive sulfide deposits which have been extensively mined, particularly for copper and sulfur (Kinkel, *et al.* 1956).

Bragdon Formation: The northern third of the Quadrangle west of the Balaklala Rhyolite is dominated by an extensive dark gray slaty shale and conglomerate, the Bragdon Formation, of Mississippian age. It overlies the Copley Greenstone. Where the Bragdon formation adjoins the Shasta Bally Batholith the shales have been metamorphosed to gneiss or schist. The Bragdon formation is widespread to the north and west of the Quadrangle.

Mule Mountain Stock: The only remaining formation of significant area is the Mule Mountain Stock. This body of light colored granitic rock lies along the east edge of the Quadrangle south of the Balaklala Rhyolite. It varies at short distances from less weatherable albite granite to more weatherable trondhjemite. The light colored albite granite is quite obvious in road cuts near the east end of Whiskeytown Lake. This stock appears to be partly an intrusion emplaced from below and partly a granitization of the Balaklala Rhyolite and possibly of the more felsic parts of the Copley Greenstone (Kinkel, *et. al.* 1956).

Minor Features: Many dikes and sills of various kinds of igneous rocks occur. West of French Gulch is a swarm of diorite porphyry dikes and in other areas quartz porphyry, altogether known locally as "birdseye porphyry," so called because the centers of the feldspar phenocrysts commonly weather out, leaving a depression that somewhat resembles the pupil of an eye. In the southeast corner just east of Clear Creek and south of Placer Road (County Highway A-16) lies an area of less than 100 acres of cretaceous marine conglomerate. This conglomerate appears to be an extension of the Rector member of the Budden Canyon Formation described by Murphy, *et al.* (1964). Coarse, poorly-to-well-cemented gravels making up benches and terraces cover about 500 acres, mainly south and east of Igo but also along Clear Creek near Tower House about 2½ miles south of French Gulch. Albers (1965) correlated these gravels with the Pleistocene Red Bluff formation.

Physiography

Elevations range from about 625 feet along Clear Creek in the southeast corner of the Quadrangle to 6,359 feet at the summit of Paradise Peak *(fig. 2)*. More than 80 percent of the area can be characterized as steep mountainous but with different general topographic forms for different geological formations. In the granitic areas, streams and ravines generally radiate away from the central ridge which extends from Paradise Peak to Shasta Bally. In the part of the Quadrangle dominated by the Bragdon shales and conglomerates, the pattern is a coarse herringbone type—particularly well seen between Trail Gulch and French Gulch. The metavolcanic portion of the Quadrangle has a similar but less well defined drainage pattern. The somewhat level areas include the pediment and dissected terraces in the southeast part of the Quadrangle near Igo, along Clear Creek below Whiskeytown Dam, and along Clear Creek upstream from Whiskeytown Lake. The upstream level area includes gold dredge tailings as well as dissected terraces and a minor amount of alluvial bottomland along streams.

SOIL-VEGETATION ASSOCIATIONS

The many kinds of rocks, soils, and climate in this Quadrangle have resulted in a diverse and complex landscape. A total of 178 different phases of soils (disregarding slope) and 29 miscellaneous land types are mapped *(tables 1, 2)*, along with over 100 species of woody plants *(table 3)* in different combinations of cover and composition (Soil-Vegetation Maps, 24D-1, -2, -3, and -4). Many of these soil-vegetation combinations occur in repeating patterns and can be grouped into broad ecosystem-like units of soils and vegetation with similar characteristics and productivity.

To group the variable landscape elements in the French Gulch Quadrangle into simpler units, the area can be divided into three broad vegetation types: conifer forest, chaparral, and woodland-grass *(fig. 5)*. The forest occupies about 65 percent of the area, chaparral (shrub) type occupies about 25 percent,

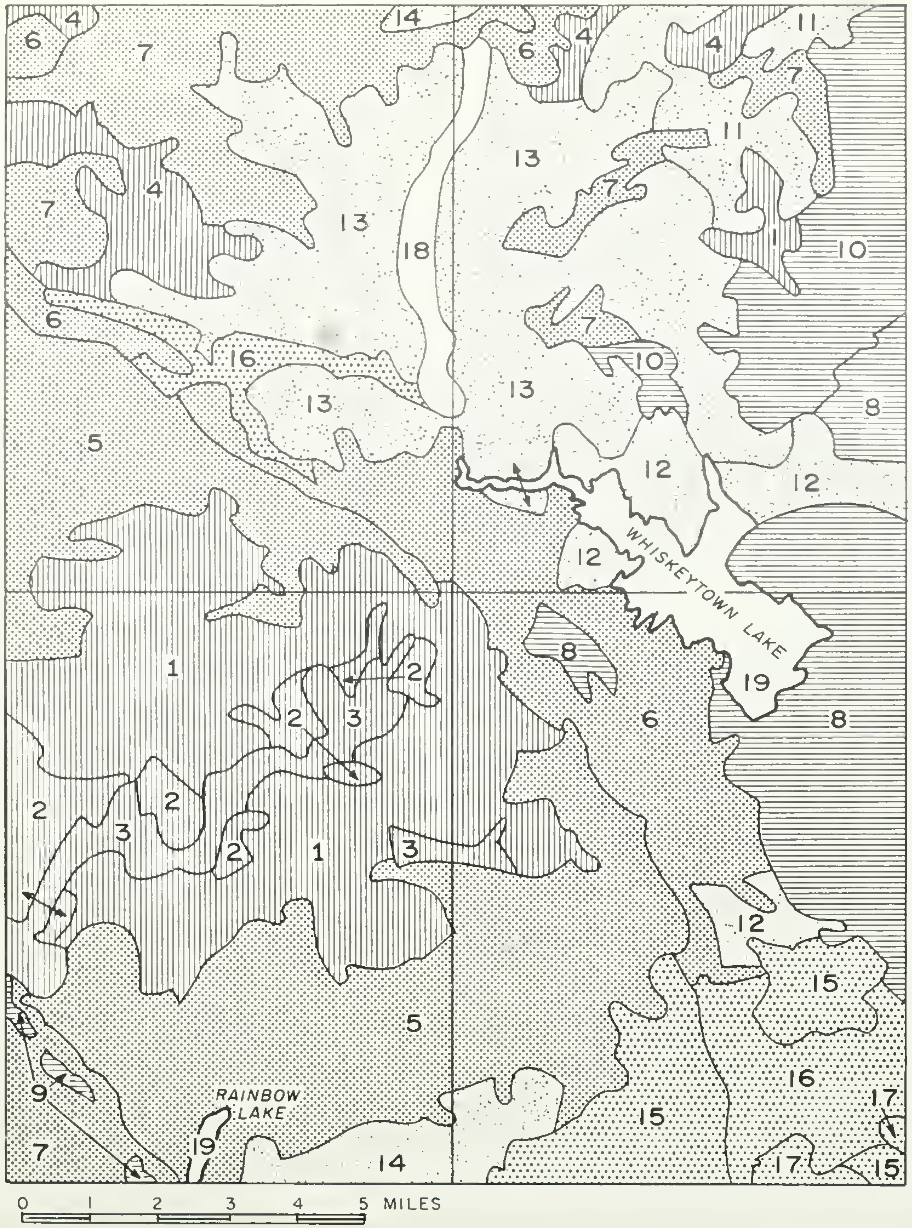


Figure 5—Soil-vegetation associations map provides identifying numbers for different combinations of soil types and vegetation types.

CONIFER FOREST TYPE

Shrub-conifer associations

1. Corbett / Shrub tanoak – mixed conifer
2. Corbett / True fir
3. Corbett / Ridge top chaparral
4. Colluvial and Rock land / Canyon live oak – Douglas-fir

Conifer-hardwoods associations

5. Chawanakee – Chaix – Holland / Ponderosa pine – Douglas-fir – California black oak
6. Neuns – Boomer / California black oak – canyon live oak – ponderosa pine
7. Sheetiron – Marpa – Josephine / Ponderosa pine – Douglas-fir – California black oak

Conifer-hardwoods-shrub associations

8. Modesty / Manzanita – California black oak – ponderosa pine
9. Huse – Dubakella / Jeffrey pine – leather oak
10. Kidd – Behemotosh / Ponderosa pine – Douglas-fir – California black oak – manzanita

CHAPARRAL TYPE

Manzanita associations

11. Maymen – Colluvial land / Manzanita – shrub oak
12. Goulding – Kidd / Manzanita – toyon

Chamise-shrub oak-Ceanothus associations

13. Maymen – Goulding – Stonyford – Los Gatos / north aspect Brewer oak, south aspect chamise
14. Eroded Chawanakee – eroded Sierra / Chamise – Lemmon ceanothus

WOODLAND-GRASS TYPE

Oak-grass associations

15. Kanaka – Sierra / Interior live oak – blue oak – annuals
16. Auburn – Millsholm – San Andreas / Blue oak – annuals – digger pine

Shrub-grass-oak associations

17. Newtown – Redding – Newville / Manzanita – annuals – blue oak

ALTERED AREAS

18. Gold dredge tailings, residential areas, and mined Horseshoe soils
19. Reservoirs – Whiskeytown Lake and Rainbow Lake

while woodland-grass occupies about 6 percent. The remaining area includes about 2.5 percent in reservoirs–Whiskeytown and Rainbow Lakes–and 1.5 percent in developed areas, including gold dredge tailings, roads, and the town of French Gulch.

Each broad type is subdivided into groups of soil-vegetation associations which have some characteristics of the soils or vegetation or both in common. The grouping of one or more soil series for each association is based on soil development, broad behavior characteristics, and major rock types, i.e., granitic, metavolcanic, sedimentary, and ultrabasic rocks (Zinke and Colwell 1965). Plant species are grouped on the basis of stature, environmental requirements, and relationships.

Seventeen associations and two altered units are mapped in the Quadrangle *(fig. 5)*. They consist of assemblages of species similar to some groups observed in the eastern Siskiyou Mountains, in the western Siskiyous (Waring 1969), in the interior valleys of southern Oregon (Franklin and Dyrness 1969), and on the north Coast Ranges, Sierra Nevada, and foothills of California (Munz and Keck 1959). These observations suggest that the vegetation of the French Gulch Quadrangle possesses elements from the north, south, east, and west not found together elsewhere.

Conifer Forest Type

Ten associations, falling into three groups, comprise the conifer forest vegetation type. Groupings are based on soils, vegetation composition, and site quality. These associations occur generally above 1,500 feet elevation and the 40-inch rainfall zone. Most of the associations can grow commercial timber *(fig. 6)*, except the Corbett/ridgetop chaparral, and the Colluvial-Rock land/Canyon live oak–Douglas-fir associations.

The first of the three association groups consists of four associations occurring at the highest elevations in the area–mostly above 3,000 feet on the north-facing slopes and above 3,500 feet on the south-facing slopes. Only this part of this Quadrangle usually has snow cover from December into April. The dominant soil is the coarse loamy sand Corbett series, derived from granitic rocks, and having little, if any, development into horizons. Corbett soils are classified as Entisols. These highly erodible soils are the source of much of the sand which is causing problems in the Salmon spawning beds of the Trinity River near Lewiston (California Resources Agency 1970). The vegetation is mostly shrub mixed with a varying percent cover of conifers of low site quality. One association in this group, mostly canyon live oak, grows on land so steep that the soil is dominantly unstable colluvial land.

The second association group has three soil-vegetation associations at middle elevations below the first group. The soils here are deeper, more developed, and redder than those in the first group, and have a greater clay content in the subsoils. Each association has a soil development sequence on three different parent materials. The first soil series in each association has soil horizons just beginning to develop and is classified in the order Inceptisols. These soils are older than the Entisols, but younger than the Alfisols. The other soils in the associations are generally Alfisols and are progressively more developed, with clay enriched B horizons that have medium base saturation. The soils in these two orders comprise most of the forest soils in the southeastern part of the Klamath Mountains geologic province. The associations in this group are generally the most productive for commercial conifers in the Quadrangle. The combination of ponderosa pine and California black oak occurs in all associations of the group. The presence of black oak is a reliable indicator of the capability of the soil to grow commercial ponderosa pine. Wieslander (1935) was one of the first to observe the close association of California black oak with commercial conifer timber sites, and used this relationship to show evidence of former pine forests from remnant black oak stands.

The third association group also has three soil-vegetation associations. Manzanita shrubs are part of the conifer-hardwood vegetation.

Shrub-Conifer Associations

Corbett/Shrub tanoak-mixed conifer: The sandy Corbett soils support an open cover of evergreen shrub species and conifers. The shrubs include shrub tanoak, canyon live oak, greenleaf manzanita, and an unusual form of squaw carpet. The conifers are dominantly ponderosa pine and sugar pine and of medium site quality. Douglas-fir, incense-cedar, and white fir are present but not as common as in the mixed conifer of the Sierra Nevada. Herbs and grasses usually cover 10 percent or less of the soil surface.

Corbett/True fir: Above about 5,000 feet elevation, white fir trees make up a larger part of the tree composition than at lower elevations. A few stands of red fir occupy north-facing slopes just below the summits of Paradise Peak, Shoemaker Bally, and Shasta Bally. Most stands are of medium site quality,

Figure 6—Generalized timber site quality map of the French Gulch Quadrangle.

a few are of low site. This association also contains shrub tanoak and non-sprouting pine manzanita, and much bush chinquapin.

Corbett/Ridgetop chaparral: Along the divide from Paradise Peak to Shasta Bally and Little Bally divide south of Brandy Creek, the Corbett soils are shallow and rocky and exposed to frequent strong winds. The association of evergreen shrubs here includes bush chinquapin, pine manzanita, greenleaf manzanita, huckleberry oak, and shrub tanoak. The few pines and firs growing in this unit are distorted by the strong winds. This association is mostly unsuitable for growing commercial timber stands economically.

Colluvial and Rock land/Canyon live oak–Douglas-fir: On steep slopes (generally over 70 percent) the soils in the forest are, in many places, loose enough so that they slide down slope at the slighest disturbance. In these areas the vegetation is dominated by either canyon live oak or Douglas-fir. In some places, the stand is a mixture of these two with California black oak and a number of shrub species as well. Most of these areas are unsuited for harvesting commercial timber crops.

Conifer-Hardwoods Associations

Chawanakee–Chaix–Holland/Ponderosa pine–Douglas-fir–California black oak: Most of the granitic southwestern third of the French Gulch Quadrangle has the shallow Chawanakee and moderately deep Chaix soils on the steep slopes. Owing to their coarse texture and lack of cohesiveness these soils are highly erodible. When eroded they continue to produce large volumes of sand with every storm because of the highly decomposed nature of the underlying granitic rock. On the more gently sloping areas–ridges, spurs, and benches–soils occur in a sequence of development–Hotaw, Holland, Musick, and Hoda soil series–with their reddish clay loam to reddish clay subsoils. This development is in striking contrast to the pale sandy loams and included loamy sands of the Chawanakee and Chaix series. These soils have a cover of California black oak, ponderosa pine, Douglas-fir, and canyon live oak, with a lower shrub layer of deer brush, greenleaf manzanita, whiteleaf manzanita, and poison oak. Site quality for commercial conifers is generally medium. Some grassy areas are found on the Hotaw, Holland, Musick, and Hoda soils. In the canyons are many bigleaf maples and some tanoaks and madrones, particularly in Rich Gulch, Salt Gulch, and the headwaters of Paige Boulder Creek between 2,000 and 3,000 feet elevation. These canyon units closely resemble the Mixed Evergreen Forest (Munz and Keck 1959; Franklin and Dyrness 1969) except for a few species.

Neuns–Boomer/California black oak–canyon live oak–ponderosa pine: Neuns soils (Inceptisols) and Boomer soils (Alfisols) are formed on greenstone or other metamorphosed basic igneous rocks. Neuns soils are generally on the steeper slopes and have gravelly loam, yellowish brown subsoils, while Boomer soils are on benches and less steep slopes and have clay loam reddish brown subsoils. The vegetation is dominated by California black oak, canyon live oak, ponderosa pine, and Douglas-fir with much whiteleaf manzanita and toyon in openings and poison oak in the understory. The Neuns soils have more canyon live oaks than do the Boomer, although California black oak is the most abundant tree on both soils. Site quality ranges from low to medium (mostly site class 3). Shallow, gravelly soils and steep slopes, along with being the lowest association in this subtype (mostly less than 2,000 feet), contribute to lower productivity for commercial conifers. Minor amounts of sugar pine, knobcone pine, incense-cedar, and Lemmon ceanothus occur in the drier, warmer parts of the association. Bigleaf maple, tanoak, and pacific dogwood occur in more moist canyons and on north-facing slopes in addition to the prevailing tree species. This association is part of Munz and Keck's (1959) Yellow Pine Forest and more specifically part of Waring's (1969) Black Oak Vegetation Type.

Sheetiron–Marpa–Josephine/Ponderosa pine–Douglas-fir–California black oak: The forest soils derived from sedimentary and metasedimentary parent materials are dominated by the Inceptisol, Sheetiron, and the Alfisols, Marpa and Josephine. In developmental sequence, Sheetiron soils have pale brown gravelly loam textures throughout, while Marpa soils have light brown gravelly clay loam B horizons, and Josephine soils have reddish brown clay loam B horizons. On some of the less steep slopes on older land surfaces, soils with red clay B horizons have developed. These soils are in the Sites series and classified as Ultisols. They are the most developed and are considered the end member of a soil developmental sequence. The vegetation is usually dominated by Douglas-fir and ponderosa pine. California black oak and canyon live oak make up most of the remainder with occasional sugar pine, incense-cedar and white fir trees. The more moist sites often have bigleaf maple, California hazel nut, shrub tanoak, and pacific dogwood in abundance. On many north-facing slopes and some northern ridgetops, shrub California black oak dominates the vegetation. This is one of the few places where extensive growth of shrub California black oak is known (McDonald 1969). Medium to low site quality characterizes this association, while on the deeper Josephine soils in the southwest corner of the Quadrangle medium sites predominate.

Conifer-Hardwoods-Shrub Associations

Modesty/Manzanita–California black oak–ponderosa pine: Along the east side of Whiskeytown Lake and Clear Creek from the northerly South Fork Mountain to Mule Mountain the dominant soils are the light brownish gray and very pale yellow Inceptisols of the Modesty series. These gravelly coarse sandy loams are formed from the granitic Mule Mountain Stock. The Chawanakee and Chaix soils west of Clear Creek are similar but are cooler and have more deeply weathered parent rock. The Kanaka soils to the south and east are similar, but have heavy loam subsoils, are more gently sloping, somewhat warmer, and support woodland-grass vegetation rather than forest. Included within the Modesty association are many small areas of Diamond Springs soils–Ultisols with very strongly acid reddish clay loam B horizons. These have similar vegetation, but are found at lower elevations and have gently sloping topography in contrast to the steep land common to most Modesty soils. The vegetation of this association consists of California black oak, canyon live oak, whiteleaf manzanita, poison oak, and Lemmon ceanothus with scattered ponderosa and sugar pines. On south-facing slopes whiteleaf manzanita dominates, but toyon, scattered Digger pine, some stands of knobcone pine, and a few ponderosa and sugar pines are present. Here site quality is low. The Modesty association is somewhat unusual in having ponderosa and sugar pines growing where the mean annual temperature is above 59°F. On gentle slopes and north aspects site quality is medium with mostly site class 3. The northern part of this association was subjected to sulfur dioxide smelter fumes from 1896 to 1906 (Kraebel 1955). The fumes destroyed most of the vegetation and very likely contributed to the strongly acid nature of the subsoils on the more gentle slopes. The vegetation is still recovering.

Huse–Dubakella/Jeffrey pine–leather oak: This distinctly different association–covering only a few hundred acres–is found on a narrow and interrupted belt of ultra-basic rocks across the southwest corner of the Quadrangle. The soils include the shallow rocky Inceptisols of the Huse series, the somewhat deeper Alfisols of the Dubakella series from the serpentinized part of the ultra-basic rock, and some colluvial land with a significant amount of ultra-basic soil material included. The vegetation consists of an open stand of Jeffrey pine and incense cedar with numerous leather oak bushes. A small amount of sugar pine and wedgeleaf ceanothus is also present as is a sparse bunchgrass ground cover. Leather oak is known to grow only on soils derived from ultra-basic rocks. Most soils from these parent materials support Jeffrey pine stands rather than ponderosa pine. Site quality ranges from unsuited to low and medium.

Kidd–Behemotosh/Ponderosa pine–Douglas-fir–California black oak–manzanita: Behemotosh and Kidd soils, Alfisols and Entisols, respectively, are formed on the Balaklala Rhyolite mainly in the north eastern part of the Quadrangle north of the northerly South Fork Mountain. The Behemotosh soils are gravelly loams over cobbly clay loams about 2 feet deep generally on ridges and steep slopes. On gentler slopes a deeper, non-gravelly, non-cobbly variant occurs. These soils have vegetation dominated by ponderosa pine, Douglas-fir, sugar pine, and California black oak. Site quality is mostly low, with some areas in the low-medium class. The many small openings in the tree canopy contain several species of manzanita, shrub tanoak, and sierra gooseberry. Below 2,500 feet elevation, the only manzanita species is whiteleaf manzanita. Above 3,000 feet, whiteleaf manzanita is absent. The only manzanitas present are greenleaf manzanita and a new hybrid which we are calling Balaklala manzanita. The new hybrid was discovered in 1968 by James I. Mallory.

Chaparral Type

Chaparral, a dense thicket of stiff or thorny shrubs or dwarf trees (Sampson and Jesperson 1963), is well known in California and other areas that have a hot, dry season and a cool, wet season. These many kinds of shrubs–chamise, manzanitas, shrub oaks, and shrub forms of some tree species–grow on steep, rocky, slopes of shallow and colluvial soils that will not support tree vegetation. In some areas, near the margins of chaparral types, shrubs will encroach rapidly on the deeper, better soils that have been logged over or periodically burned and where accelerated erosion has begun.

The chaparral type in the French Gulch Quadrangle is divided into two association groups with two soil-vegetation associations (Nos. 11 through 14) in each. The associations are based on the soil properties, dominant vegetation, and slope aspect.

Manzanita Associations

Maymen–Colluvial land/Manzanita–shrub oak: Maymen soils, gravelly loam Inceptisols, are found on the steep slopes and ridges of sedimentary rocks in close association with unstable very gravelly Entisols (unclassified as to series) on the adjacent colluvial land. The vegetation consists of a dense shrub cover on the Maymen soils and a more open shrub cover on the colluvial land. Greenleaf manzanita and shrub California black oak (McDonald 1969) dominate the vegetation in this association (as well as in part of the Sheetiron–Marpa–Josephine/Ponderosa pine–Douglas-fir–California black oak association). In parts of this association, Balaklala manzanita, Fremont silk tassel, shrub tanoak, knobcone pine, and canyon live oak are dominant. Herbaceous cover is practically nonexistent.

Goulding–Kidd/Manzanita–toyon: Below 2,000 feet elevation on the south-facing slopes near the Whiskey Creek arm of Whiskeytown Lake are shallow soils formed on metavolcanic rocks. These are the Goulding series and Kidd series (Inceptisols), formed from greenstone and meta-rhyolite. The vegetation is an open to semidense stand of shrubs–mostly whiteleaf manzanita and toyon. In places Brewer oak, shrub interior live oak, buck brush, knobcone pine, and canyon live oak are prominent.

Chamise-Shrub Oak-Ceanothus Associations

Maymen–Goulding–Stonyford–Los Gatos/north aspect Brewer oak: This most extensive of the chaparral associations occupies the north-facing slopes in an area about 7 miles in diameter centered on the town of French Gulch. The Maymen and Goulding soils are Inceptisols formed on sedimentary and metavolcanic rocks respectively. Stonyford soils are shallow Alfisols with reddish brown gravelly clay loam subsoils in contrast to the yellowish brown gravelly loam subsoils of Maymen and Goulding. Los Gatos soils are similar to Stonyford soils but have dark brown surface horizons thicker than 10 inches (which places them among the Mollisols) and are formed from sedimentary rock. The vegetation is dominated by Brewer oak, shrub interior live oak, western mountain mahogany, and California black oak. Intertwined among these shrubs is poison oak, chaparral honeysuckle, and pipestem clematis. The understory consists of several species of annual and perennial grasses and forbs providing sparse ground cover (see plot 14, Quadrangle 24D-1, *table 4* and *table 5* for detailed information). At higher elevations the Maymen–colluvial land/Manzanita–shrub oak and the forest associations containing Marpa or Neuns soils are found in similar slope positions.

Maymen–Goulding–Stonyford–Los Gatos/south aspect chamise: Just over the ridges on the south-facing slopes, on the same kinds of soils but shallower and more eroded than in the association described above, the cover is an almost impenetrable brushfield of chamise with some associated buckbrush, whiteleaf manzanita, and toyon. Herbaceous vegetation is sparse (plots 1-3, Quadrangle 24D-1, *table 4 and 5*). Extensive areas of chamise, the most typical and widely known of the California chaparral types, are found from here south to Baja California. Chamise is found in a few small patches further north, but the very northernmost known natural growth is only 21 miles northeast of French Gulch, near Delta Point in the Sacramento River canyon (U.S. Forest Service 1939).

Eroded Chawanakee–eroded Sierra/Chamise–Lemmon ceanothus: Between Rainbow Lake and Eagle Creek, along the south edge of the Quadrangle is a steep, brush covered, eroded area with a rather unique bench or step topography. The vegetation is a semidense stand of chamise, manzanitas, and Lemmon ceanothus with widely scattered ponderosa pine and California black oak. Chawanakee and Chaix soils from the forest zone and Sierra soils from the woodland grass zone are intermingled in a unit differing from either of the normally associated vegetation types.

Woodland-Grass Type

The Woodland-Grass, or Foothill-Woodland of Munz and Keck (1959), is an extensive zone in California completely encircling the central valley and covering much of the coast ranges and parts of southern California.

The Woodland-Grass area of the Quadrangle consists of about 9,000 acres of gently sloping to steep rangeland centered on Igo in the southeast corner and about 1,000 acres on very steep south-facing slopes along Highway 299 from the French Gulch junction to Trail Gulch and up Trail Gulch 2½ miles. Three soil-vegetation associations are recognized that differ in soil characteristics, vegetation, and forage production. A few areas within or adjacent to the Woodland-Grass type have been so altered by human activity that they are best considered just as "altered areas" rather than soil-vegetation associations.

Oak–Grass Associations

Kanaka–Sierra/Interior live oak-blue oak–annuals: On the granitic pediment at the southeast end of the Shasta Bally batholith and the lower parts and south-facing slopes of the Mule Mountain stock three soil series with intergrading characteristics and contrasting profiles occur. These soils are highly erodible. Therefore, they need more careful management than nearby non-granitic soils to prevent soil loss and gullying. The Inceptisols are represented by the Kanaka series, brown sandy loams with very pale brown heavy loam or sandy loam subsoils grading into weathered granitic rock at 2 feet or more. The Alfisols include the Auberry series, similar to Kanaka but with brown sandy clay loam subsoils, and the more extensive Sierra series with their yellowish red sandy clay loam subsoils. The three soils represent a development sequence. Open to dense stands of interior live oak with scattered blue oak, Digger pine, valley oak, and a ground cover of annual grasses and forbs make up most of the vegetation. Estimated suitability for extensive range use would be medium except for the badly eroded areas which are unsuited for grazing (plot 1, Quadrangle 24D-4, *table 4*). A few small groups of ponderosa pines occur on the deeper soils.

Auburn–Millsholm–San Andreas/Blue oak–annuals–Digger pine: The three dominant soils in this association are formed from different parent materials, Auburn from greenstone, Millsholm from shale, and San Andreas from schist. The Auburn soils are reddish silt loam Inceptisols with hard bedrock between 1 and 2 feet down. Associated with the Auburn are small areas of Exchequer soils, similar but less than 1 foot deep, and Sobrante soils with clay loam B horizons and up to 40 inches deep to weathered greenstone or schist. Millsholm soils are brown silt loam Inceptisols with platy shale or slate at 10 to 20 inches. San Andreas soils have thick dark brown surface horizons (making them Mollisols) and fine sandy loam textures with schist bedrock at 20 to 40 inches. Depth to this bedrock is variable in short distances as the schist consists of vertical plates less than an inch thick of variable weatherability. This belt of schist lies along the east side of the Shasta Bally granitic mass. Vegetation in this association is an open to dense stand of blue oak, Digger pine, annual grasses and forbs, with varying amounts of shrubs from adjacent chaparral areas. Plot 5, Quadrangle 24D-2, in *tables 4 and 5,* represents this association but with somewhat less herbaceous matter and more brush than typical. For forage production, this association would be rated medium to low.

Shrub-Grass-Oak Associations

Newtown–Redding–Newville/Manzanita–annuals–blue oak: Newtown and Newville soils have gravelly loam A horizons with clay B horizons starting at 10 to 20 inches, which grade into the weakly consolidated gravelly sediments of the Pleistocene Red Bluff formation. Newville soils differ from the Newtown soils in having darker surfaces, a more abrupt boundary between the A horizons and the B horizons, and in having greater percentage of clay in the B horizon. They were not separated on the map because of their close similarity. The Redding soils occur on the level tops of some of the terraces formed by the Red Bluff formation. In part of the area they have hummocky microrelief with mounds about 10 to 20 feet apart and a difference in elevation of 6 to 10 inches between the mounds and the level above which they rise. The most important characteristic of the Redding soils is the impenetrable iron-silica cemented hardpan which lies about 20 inches below the surface. The vegetation in this association consists of patches of whiteleaf manzanita, sparse cover of annual grasses and forbs, and scattered blue oaks. The cover is more open on the Redding soils than on the others in this association. Suitability for extensive range use is low. Powell (1965) found that Redding soils responded to nitrogen and phosphorous when added together but there was no response when added singly, and no response to added sulfur.

Other Associations: In this Quadrangle, several other shrub-grass-oak associations occur but are too small in size to include within the broader groupings of the soil-vegetation associations. However, these smaller units may occur extensively in other Quadrangles.

Altered Areas

Gold dredge tailings, residential areas, and mined Horseshoe soils: The valley and terrace land along Clear Creek has been disturbed by mining activities producing ridges of cobbly dredger tailings and vertical red cliffs in the remnants of the dissected Horseshoe soils. Much of the tailings area has been leveled and is being used for building and mobile home sites.

Reservoirs–Whiskeytown Lake and Rainbow Lake: Whiskeytown Lake covers over 3,000 acres in the east central part of the Quadrangle. The reservoir covered the site of a stand of MacNab Cypress and is reputed to be the discovery site of this species. This particular stand was the only well publicized and easily accessible grove (Griffin and Stone 1967). At least one MacNab Cypress tree from the Whiskeytown grove remains, where it was transplanted, northeast of the Whiskey Creek arm of Whiskeytown Lake in Section 9, Township 32 North, Range 6 West, M. D. M. Most of the Whiskeytown Reservoir area was occupied by the Goulding–Kidd/Manzanita–toyon association, with additional stands of the MacNab Cypress and Knobcone pine.

Rainbow Lake, a reservoir of about 100 acres, in the southwest corner of the Quadrangle, appears to be filling with sand from the granitic soils in its watershed of about 8,000 acres.

TIMBER SITE QUALITY

In the French Gulch Quadrangle, more than 71 percent (100,000 acres) of the land is suitable for growing commercial conifers *(fig. 6)*. The area has adequate rainfall, usually 40 inches or more, but the relative capacity of the land to grow timber as measured by site class will depend on such additional factors as soil depth, texture, stoniness, slope, aspect, and elevation.

The highest site (site class 5) occupies less than 1 percent of the commercial timber area. It occurs on the deep soils of less steep slopes, in draws, and on north-facing slopes. Of the medium sites, site class 4 occupies more than 30 percent of the commercial timber area. Located between 2,000 and 4,000 feet elevation, this site is characterized by the medium-textured soils of the conifer-hardwoods associations. The largest portion (59 percent) of the timber area is site class 3. Less deep, coarse-textured soils, south aspect and steep slopes are characteristics of this site. Many areas are transitional zones to the chaparral and woodland-grass types.

The balance of the commercial timber area—about 10 percent—is site class 2. This site reflects the adverse climatic conditions on high ridge tops that have erodible, shallow, sandy soils, and the hot, dry areas adjacent to chaparral types of southern exposure at lower elevations. Most all areas of site class 2 and 3 have shrubs associated with the conifer-hardwood vegetation.

NEW SOILS AND PLANTS

In the investigation of the French Gulch Quadrangle, we discovered a number of new soils, and new or little-known shrubs. The new soils include a new series and three variants. The new shrub is a gray leaved, non-sprouting manzanita and the little-known shrubs include two other manzanitas, and a variety of squaw carpet.

New Soils

Modesty Series

The Modesty soil series *(tables 1, 2)* shown as map symbol 721 on the soil-vegetation maps is a distinctive new soil series described for this Quadrangle. Because it has not yet been correlated by the National Cooperative Soil Survey, a formal description of this group of soils is not available.

The soils of the Modesty series are classified in the coarse-loamy, mixed, thermic family of Typic Xerochrepts (Soil Survey Staff 1970). They are well to excessively drained, moderately coarse textured upland soils developed from weathered granitic rock. They occur on steep to very steep slopes, under mixed stands of shrubs, hardwoods, and conifers at elevations of 800 to 3,000 feet in the foothills of the Klamath Mountains and Sierra Nevada of northern California. Annual precipitation ranges from 40 to 70 inches. Mean annual temperature is about 60°F., average January temperature is 44°F., and average July temperature is about 79°F. Frost-free period is 180 to 240 days.

These soils are shallow to moderately deep and have light gray, strongly acid, gravelly sandy loam surface horizons and nearly white to light yellowish brown, strongly acid loam subsoils.

Commonly associated with the Modesty soils are other timber soils of the Chawanakee, Behemotosh, Diamond Springs, Neuns, and Boomer series and the woodland-grass shrub soils of the Kanaka, Kidd, Goulding, and Auburn series.

A representative soil profile on a 49 percent west-facing slope under a semidense stand of whiteleaf manzanita, toyon, California black and canyon live oaks, elevation 2,200 feet (1 mile south of South Fork Mountain Lookout in the southeast one-fourth of Section 10, T. 32N., R. 6W.) is described as follows:

O1–1 to 0 inch, scattered litter of shrubs and oaks, with some erosion pavement of gravels and a few small cobbles.

A1–0 to 3 inches, light brownish gray (2.5Y 6/2) gravelly sandy loam, dark grayish brown (2.5Y 4/2) moist; weak fine and medium subangular blocky to granular structure; slightly hard, friable, slightly sticky and slightly plastic; abundant very fine roots; few very fine tubular and many very fine interstitial pores; strongly acid (pH 5.5); gradual smooth boundary; 1 to 6 inches thick.

A3–3 to 6 inches, light gray (2.5Y 7/2) sandy loam, pale brown (10YR 6/3) moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky to slightly plastic; few very fine, fine and medium roots; many very fine and fine interstitial and few very fine tubular pores; strongly acid (pH 5); gradual smooth boundary; 2 to 8 inches thick.

B2–6 to 20 inches, white (2.5Y 8/3) loam, light yellowish brown (10YR 6/4) moist; massive; slightly hard, firm to friable, slightly sticky to slightly plastic; few very fine, fine and medium roots; many very fine and fine interstitial and few very fine tubular pores; strongly acid (pH 5.5); abrupt irregular boundary; 10 to 25 inches thick.

C–20 to 40 inches, soft weathered albite granite, with few very fine roots and few thin clay bridges; strongly acid (pH 5.5); grades into hard albite granite at about 40 inches.

Colors range from gray to very pale brown in the 10YR and 2.5Y hues on the surface and from white to pale yellow and very pale brown in the 2.5Y and 10YR hues in the subsoil. Textures range from gravelly very coarse sandy loam to sandy loam in the surface, and from gravelly loam to coarse sandy loam in the subsoil. The soil reaction usually changes little with depth, but may range from slightly acid to strongly acid in the profile. Depth to weathered rock is variable in short distances, but normally ranges from 12 to 30 inches. Hard granitic rock may be found at depths from 30 inches to more than 30 feet.

Modesty gravelly sandy loam is usually excessively drained. Surface infiltration is rapid and the permeability is moderately rapid to rapid. Runoff is slow to moderate. Under dense vegetative cover and gentle slopes, erosion is slight to moderate. But on steep slopes that have heavy removal of vegetation either from fire or logging, the erosion hazard is high to very high. Available water-holding capacity is low to medium. Fertility is low.

The Modesty soils are of low to medium site quality for timber production. Because of the predominance of shrub and hardwood vegetation cover, the main use is for watershed and wildlife habitat.

Tish Tang Variant 2

The Tish Tang Variant 2 soils differ from the typical Tish Tang soils primarily in being shallower (20 to 40 inches to bedrock rather than 72 to 120 or more). They differ from the Tish Tang Variant soils of the Hoopa Quadrangle (DeLapp and Skolmen 1961) in having the normal pale brown subsoils rather than mottled subsoils. The Tish Tang Variant 2 soils have a varying amount of shale fragments in the surface few inches derived from the adjacent Bragdon formation and some diorite porphyry fine gravels near the bedrock.

Behemotosh Variant

Behemotosh Variant soils differ from typical Behemotosh soils in having clay loam textures rather than very gravelly or cobbly clay loams, and very strongly acid subsoils rather than moderately acid subsoils. They are usually found on gently sloping plateau-like areas above 3,000 feet in areas where rhyolite is the bedrock.

Fiddletown Variant

Fiddletown Variant soils differ from Fiddletown soils in having clay loam subsoils rather than stony or gravelly loams as found in typical Fiddletown soils.

New and Little-Known Shrubs

Balaklala Manzanita

The new hybrid *Arctostaphylos canescens x viscida,* which we are calling Balaklala manzanita, is found in this Quadrangle *(table 3).* This shrub resembles *A. canescens* Eastwood, but is generally smaller (1 to 5 feet tall) and has bracts of the inflorescence distinctly shorter than the flower pedicels, a key character among manzanitas. Balaklala manzanita grows on the highland between Clear Creek and the Sacramento River above 2,500 feet in openings in the forest and in the upper part of the chaparral associations. Gankin[2] reports having found it on Red Mountain in Mendocino County, California.

Other Manzanitas

Eight species and subspecies of manzanita were noted in the French Gulch Quadrangle. Two others

---

[2]Personal communication with Roman Gankin, formerly with University of California Arboretum, Davis, May 2, 1973.

have recently come to the attention of botanists. One individual of Roof manzanita, *A. Roofii* Gankin, was found on the Trinity divide within 200 yards south of Buckhorn summit and several shrubs that appear to be Shingletown manzanita, *A. manzanita* ssp. *Wieslanderi* Philip V. Wells, were seen along the ridge road west of Iron Mountain.

Trinity Squaw Carpet

Trinity squaw carpet *(Ceanothus prostratus* Benth. var. *laxus* Jeps.*)* is an open, somewhat upright, form of the dense, prostrate *Ceanothus prostratus* Benth. It is distinctive in the shrub landscape of the Corbett/shrub tanoak-mixed conifer association. This variety was previously known only from Hot Springs Valley near Mount Lassen 70 miles to the east (Jepson 1925), from a few places on the Sierra Nevada (McMinn 1942), and from the headwaters of New River 40 miles to the northwest.[3] Although McMinn (1942) recognized the variety, his description says nothing about the open, upright, habit which Jepson apparently used to distinguish the variety. McMinn's concentration on fruit and leaf characters, which aren't greatly distinguishing in this case, may be the reason that Munz and Keck (1959) reduced the variety to synonmy under *C. prostratus.* Trinity squaw carpet is mapped on about 2,000 acres on Buckhorn Mountain and Shoemaker Bally *(table 3).*

LEGEND TO THE MAPS

Base Maps

Base maps used for the Soil-Vegetation maps are specially prepared by the Pacific Southwest Forest and Range Experiment Station, mostly from published sources. Each Soil-Vegetation map consists of a standard 7½-minute quadrangle unit at the scale of 2 inches = 1 mile.

Every effort has been made to fit the soil and vegetation boundaries to the topography of the base map. Land subdivisions have been positioned as accurately as source information and map control points permit. If a precise fit of the data to land subdivisions for small areas is required, ground checks against known corner locations, fence boundaries, or other features should be carried out, preferably by using aerial photographs.

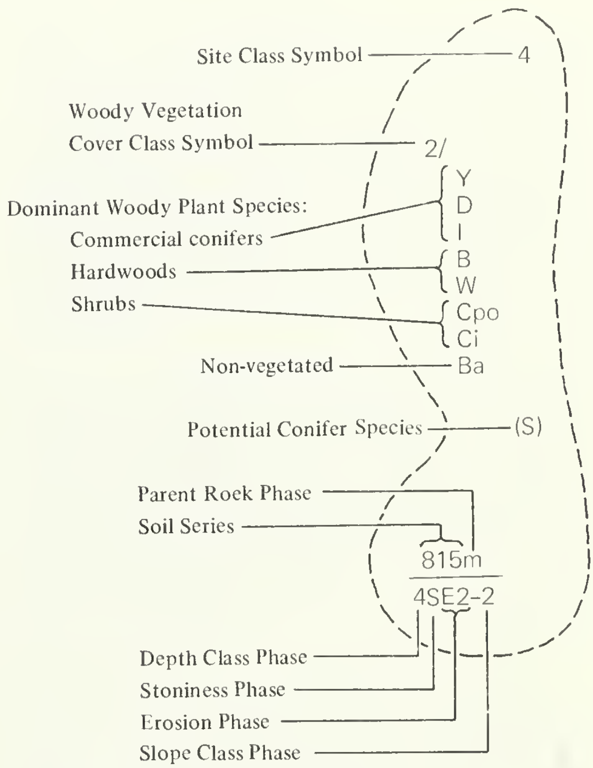
Contour lines, minor roads, small drainages, and other map details are not shown on the maps so as not to obliterate other data. If such map detail is required, refer to maps used as sources for the base information. These maps are listed in the lower right corner of each quadrangle map.

Soil Symbols

Soils are mapped by soil series and phases (depth class, slope class, and certain other soil phases). The Soil Survey Manual (Soil Survey Staff 1951) has been used as a general standard of reference for terminology and concepts. Soils are designated by symbols written as fractions, e.g.:

$$\frac{815}{4S\text{-}1} = \frac{\text{Soil Series}}{\text{depth class/other phases/-slope class}}$$

The various symbols used in a delineated mapping area are shown in the diagram below:



Soil series names are designated by three or four digit numbers in the numerator of the fraction. Soil series variants are soils of limited extent which are

---

[3]Personal communication with Helen K. Sharsmith, Senior Herbarium Botanist, University of California, Berkeley, Sept. 11, 1962.

distinctly different but similar and closely related to a known soil series. These are designated by the symbol "V" following the soil series symbol, e.g. 815V. *Parent rock* phases *(table 1)* are designated by a lower case letter symbol following the soil series symbol, e.g. 815m.

Other soil phases are designated by letters and numbers in the denominator of the fraction. Soil *depth class* is designated by the first digit. *Rockiness, stoniness, and/or erosion* are designated by letters and numbers immediately following the depth class symbol *(table 2)*. The *slope class* in the delineated area is represented by a letter or number symbol which is separated by a hyphen from the other phase symbols *(table 1)*.

In some areas an association of two soils occurs in such an intricate pattern that they cannot be indicated separately at the scale of mapping. Such a *soil complex* is designated by two fractional symbols separated by a vertical line, e.g.,

$$\frac{847}{2\text{-}2}\Big|\frac{752}{3\text{-}2} \quad \text{or} \quad \frac{847 \mid 752}{3\text{-}2}$$

The dominant soil unit (51 to 80 percent of a delineated area) appears on the left.

Unclassified soil areas are usually agricultural or potentially agricultural lands for which, in many cases, soil surveys have already been made by other agencies, such as the U.S. Soil Conservation Service. Symbols for unclassified soils are "100," "200," or "400," but are not in fraction form; sometimes a letter follows the number indicating further breakdown of the general definition of the symbols, e.g., 200W *(table 1)*.

Miscellaneous land types have little or no soil, or soil that cannot feasibly be classified. They are distinguished as a group by the symbol "700," also not in fraction form. Subdivisions within the groups are shown by letter symbols in parentheses following the "700" symbol, e.g. 700(CK) *(table 1)*.

Soil Classification

Classification System

The soil classification system currently used was adopted for general use in the United States in 1965 (Basile 1971; Soil Survey Staff 1960). It has six categories. The broadest category is the order, followed by suborder, great group, subgroup, family, and the series. The criteria used as a basis for classification are soil properties that are observable and measurable. The placement of the smallest unit—the soil series—in the current system may change as more precise information becomes available.

The 10 soil orders recognized are defined as follows:

Entisols: young mineral soils that do not have genetic horizons or barely have the beginning of such horizons.

Inceptisols: mineral soils in which horizons have started to develop, and are young but not on recent land surfaces.

Mollisols: very dark colored and base-rich soils with a thick, friable, dark-colored surface layer.

Alfisols: soils that have clay-enriched B horizons with medium or high base saturation and usually have light-colored surface horizons.

Ultisols: well developed soils that have clay-enriched B horizons with low base supply or low base saturation decreasing with depth.

Vertisols: clayey soils that shrink and have wide deep cracks during dry periods and that swell closing the cracks, in moist seasons.

Aridisols: primarily soils in dry areas, pale in color and generally soft when dry or have distinct structure.

Spodosols: usually gray to light gray podzol or podzolic soils, generally infertile, and developed from siliceous parent materials in cool humid climates.

Oxisols: reddish, yellowish, or grayish soils of tropical and subtropical regions, are deeply weathered, and formed on gentle slopes on old surfaces.

Histosols: soils that are dominantly organic from bogs, peats, and mucks.

Classification of Soils

The placement of the soil series of the French Gulch Quadrangle in the current soil classification system is still tentative because both the soils and the system are under continual study. Five orders are represented in the Quadrangle: Entisols, Inceptisols, Mollisols, Alfisols, and Ultisols. They are further classified by subgroup and family *(table 6)* (Soil Survey Staff 1972).

Vegetation Symbols

Plant species are represented by letter symbols, such as Af for chamise *(Adenostoma fasciculatum)* and D for Douglas-fir *(Pseudotsuga menziesii) (table 3)*. Dominant species in a delineated area (excluding individual grass species and most associated herbs) are indicated by one or more symbols which may be grouped. Each group of symbols represents an element which may be either a broad kind of vegetation (commercial conifers, minor conifers, hardwoods, shrubs, bushy herbs, grass, marsh) or some other landscape unit (nonvegetated and rock, cultivated, urban-industrial). Each delineated area may have one or more elements occupying from 5 to 100 percent of the ground area. Elements can be determined on the map by grouping the appropriate symbols. For example, an area has the symbols Y D I B W Cpo Ci Ba. They represent four elements, respectively: commercial conifers (YDI), hardwoods (BW), shrubs (CpoCi), and non-vegetated (Ba).

Elements are listed in order of abundance with the one listed first making up the greatest proportion of the cover. Likewise, the order of symbols within an element indicates the relative abundance of the species within that element. Symbols of vegetation elements not classified as to species (grass, marsh, and bushy herbs) and the non-vegetation element (barren) are included among plant symbols in proper order of abundance of elements or may stand alone as the case may be.

In the above example, there is a greater proportion of commercial conifers than hardwoods, shrubs, or grass, and there is more Y than D, more D than I. But the proportion of I is not necessarily greater than B or Ba. If five or more species symbols appear in one group, the relative abundance of the species is variable within the delineated area. For further information on the classification system, see the folio titled "Timber Stand and Vegetation-Soil Maps of California," Jan. 15, 1949 (U.S. Forest Serv. California Forest and Range Exp. Stn. 1949), and the "Field Manual, Soil-Vegetation Surveys in California" (U.S. Forest Serv., California Forest and Range Exp. Stn. 1954).

A species must occupy 20 percent or more of the crown space of the element to which it belongs to be mapped in a delineated area. The individual element also must comprise the following minimum parts of a delineated area: crowns of commercial conifers—5 percent or more of the ground space; hardwoods and minor conifers—each at least 5 percent, or 20 percent when in combination with 20 percent or more of commercial conifers; shrubs—at least 5 percent, or 20 percent when in combination with 20 percent or more of a tree element; and all other elements—at least 20 percent if they appear on the map.

In some areas, logging, burning, or clearing may have eliminated one or more (or all) species of commercial conifer trees. In such areas, symbols of conifers eliminated or reduced to less than 5 percent cover are shown in parentheses.

The approximate percent of the ground covered by woody vegetation (i.e., canopy of all trees and shrubs combined) is shown as a *cover* class symbol which appears as a number above or to the left of the vegetation species symbols and separated from them by a line, e.g., 2/YDIBWCpoCiBa. The cover class symbols and explanation are:

	Cover class	*Ground covered (percent)*
Cover symbol:		
1	Dense	> 80
2	Semidense	50 - 80
3	Open	20 - 50
4	Very open	5 - 20
5	Extremely open	< 5

In some areas, distinct vegetation units cannot be shown separately at the scale of mapping. In such cases, two groups of cover class and species symbols are shown with a vertical line separating them, e.g.,

1	2
D	T
R	M
T	Ba

Type-acre soil-vegetation sampling plots are established in a mapped area. These plots are not uniformly distributed because their locations are chosen to be representative of the more extensive (or sometimes unusual) combinations of soil and vegetation. A detailed soil profile description and intensive vegetation inventory are made at these sites. Plot locations *(tables 4, 5)* are shown on the map by circled numbers, e.g.,③.

Timber Site Symbols

Site quality (capacity of the land for growing timber) is indicated on the map by Arabic numbers. Pine, fir, pine–Douglas-fir, and pine–Douglas-fir–fir types are graded in terms of the total height that average dominant trees reach at 300 years of age, by 25-foot classes (Dunning 1942). These classes are designated by numbers 1 through 6:

Class symbol:	*Site Index Height of dominant trees At 100 years*	*At 300 years*	*Site class symbol used by Forest Service, Calif. Region*
	(feet)		
1	52	75	V
2	67	100	IV
3	82	125	III
4	102	150	II
5	122	175	I
6	140	200	IA

In areas without climate and soil suitable for growing commercial conifer timber crops, the site index symbol is omitted.

Soil and Vegetation Boundaries

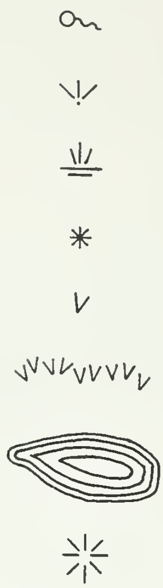
Soil or vegetation boundaries or both are normally shown on the map by dashed lines. In some places, however, it is necessary to show a soil boundary distinct from a vegetation boundary. Where this is done, a dotted line indicates a soil boundary. When needed, a double-headed arrow is used to show the appropriate adjacent soil.

Other Features on Map

Photo centers: The locations of the centers of aerial photographs from which the map data are compiled are shown on the map by large dots. This will facilitate use of the map with aerial photos.

Roads: Some are shown for orientation purposes.

Special features: Features too small to delineate are shown by these symbols:



Spring

Wet spot

Small marsh or wet meadow

Severely eroded spot

Prominent rock outcrop

Rock escarpment

Pond or reservoir

Named peak

TABLES TO ACCOMPANY MAPS

Explanation of Tables

Table 1 lists the soil series mapped in the Quadrangle and gives the more important characteristics of each. The soil series names used in this report are based on present concepts of the series and are subject to review and final correlation. Variations must be expected in characteristics listed, as terms (except slope class) apply to the soil series in general. Detailed descriptions of individual soil series are on file at the University of California, Departments of Soils and Plant Nutrition at Berkeley and Davis.

Table 2 gives a legend for soil series, phases, and other units mapped, other than slope, including permeability, general drainage, erosion hazard, and suitability for commercial timber production, and for extensive range use.

Table 3 lists the symbols of plant species and other landscape units occurring on the maps, and symbols of species not mapped due to scale of mapping, but recorded on type-acre plots or observed in the Quadrangle area. Common (Jepson 1923; McMinn 1939) and scientific names (Munz and Keck 1959; Munz 1968), growth habit, sprouting nature, and browse values are given for each species. Browse values are based on values reported by Sampson and Jespersen (1963).

Table 4 presents a portion of the data taken from type-acre sampling plots that is principally concerned with livestock and wildlife use. It includes date of sampling, plot location, aspect and percent slope, soil series and phases, woody cover class (overstory), information on soft chess growing on the plot, percent of ground covered by various vegetation and landscape units as measured below a reference plane 4½ feet above the ground, and a list of woody species with available browse.

The soil series, soil phase, and woody cover class symbols may not correspond to those in the delineated areas of the map in which the plots are located because of scale of mapping. Detailed descriptions of soil profiles at these plot locations are on file at the Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Soft chess *(Bromus mollis)* is one of the most common annual range grasses in California. Height and stage of maturity of this grass together with date of sampling and other data give an indication of site and kind of season or year for the plot area.

Table 5 lists scientific (Munz and Keck 1959) and common (Abrams 1923-1960; Jepson 1923; Munz and Keck 1959) names of herbaceous species found on the type-acre plots described in *table 4.* Because percent cover *(table 4)* and composition of herbaceous species often vary from year to year, these are preliminary data describing the plots at date of sampling. More data on percent composition and abundance of plants are on file at the Department of Agronomy and Range Science, University of California, Davis.

Table 6 lists the five orders of soils found on the Quadrangle: Entisols, Inceptisols, Mollisols, Alfisols, and Ultisols, by soil series, family, and subgroup.

Tables

Table 1 --Soil symbols and some important characteristics of soil series mapped

Soil series symbol	Soil series name	Depth range (inches)	Color of surface/subsoil	Texture of surface/subsoil	Reaction of surface/subsoil	Parent material	Relief and slope classes mapped1/
200	2/						
242	Greenfield	31-60+	Brown/brown	Sandy loam/heavy sandy loam	Slightly acid to neutral/neutral to mildly alkaline	Granitic alluvium	Nearly level to gently sloping (A,B)
400	2/						
522	Redding	10-28 to hardpan, otherwise 60+	Reddish brown/ red	Gravelly loam/ gravelly clay over hardpan	Strongly to slightly acid/ strongly acid	Old gravelly mixed alluvium	Nearly level to rolling, hummocky (A,AB,B,C)
700	2/						
7117	Musick and Hoda3/	35-60+	Grayish brown or brown/yellowish red or red	Sandy loam or loam/sandy clay or heavy clay loam	Moderately acid/ strongly acid	Granitic rock	Gently sloping to steep (C,CD,D,2)
7118	Boomer	30-56	Light brown/ reddish brown	Gravelly loam/ gravelly clay loam	Moderately acid/ moderately acid	Metamorphosed basic igneous rock4/	Hilly to very steep (CD,D,1,2,3)
7118m	Boomer (schist)	30-56	Light brown/ reddish brown	Sandy heavy loam/ gravelly sandy clay loam	Moderately acid/ moderately acid	Schist4/	Hilly to very steep (3)
7121	Corbett	24-60+	Dark grayish brown/pale brown	Loamy coarse sand/loamy coarse sand	Strongly acid/ moderately acid	Granitic rock	Hilly to very steep (1,2,3, 4)
7125V2	Tish Tang variant 2	20-40	Pale brown/very pale brown	Gravelly loam/ loam	Moderately acid/ strongly acid	Diorite porphyry	Steep to very steep (2,3,4)
7129	Chawanakee and Chaix3/	18-60	Grayish brown/ very pale brown to light yellowish brown	Coarse sandy loam/coarse sandy loam	Moderately acid/ moderately to strongly acid	Granitic rock	Hilly to very steep (CD,D,2,3,4)
7135	Diamond Springs	20-40	Pale brown to grayish brown/ very pale brown to yellowish red	Very fine sandy loam/clay loam	Moderately to very strongly acid/strongly to very strongly acid	Fine grained acid igneous rock	Hilly to steep (CD,2)
7136	Behemotosh	20-33	Grayish brown/ reddish yellow	Gravelly loam/ cobbly light clay loam	Moderately acid/ moderately acid	Metamorphosed rhyolite	Sloping to very steep (D,2,3,4)
7136L	Behemotosh (landslide)5/	20-60+	Brown/reddish yellow	Fine sandy loam/ silty clay loam	Strongly acid/ very strongly acid	Fragmented rhyolite and soil material	Steep to very steep (2,3)

Table 1 (continued)

Soil series symbol	Soil series name	Depth range (inches)	Color of surface/subsoil	Texture of surface/subsoil	Reaction of surface/subsoil	Parent material	Relief and slope classes mapped1/
7136V	Behemotosh variant	33-50	Dark grayish brown/strong brown to pink	Loam/clay loam	Moderately acid/ very strongly acid	Deeply weathered acid igneous rock	Gently sloping to steep (2)
716	Holland and Hotaw3/	24-72+	Grayish brown/ reddish brown to light brown	Loam to coarse sandy loam/clay loam to sandy clay loam	Slightly to moderately acid/ moderately to strongly acid	Granitic rock	Hilly to very steep (D,1,2,3,4)
721	Modesty	17-30	Light brownish gray/very pale yellow	Gravelly coarse sandy loam/ gravelly loam	Strongly acid/ strongly acid	Granitic rock	Hilly to very steep (CD,2,3)
726	Dubakella	14-30	Reddish brown/ yellowish brown	Gravelly loam/very gravelly clay loam	Neutral/neutral	Serpentine	Gently sloping to very steep (2)
728	Neuns	20 - 40	Dark brown/ yellowish brown	Gravelly sandy loam/gravelly sandy clay loam	Moderately acid/ moderately to strongly acid	Metamorphosed basic igneous rock 4/	Hilly to very steep (CD,1,2,3,4)
728L	Neuns (landslide)5/	24-60+	Dark brown/ yellowish brown	Gravelly sandy loam/gravelly sandy clay loam	Moderately acid moderately to strongly acid	Fragmented basic igneous rock and soil material	Very steep (3)
728m	Neuns (schist)	15-50	Dark brown/ yellowish brown	Gravelly sandy loam/gravelly sandy clay loam	Moderately acid moderately to strongly acid	Schist4/	Hilly to very steep (2,3,4)
741	Auburn	10-28	Strong brown to yellowish red/ reddish brown to yellowish red	Silt loam/silt loam	Slightly to moderately acid/ slightly acid to neutral	Schistose to massive metamorphosed basic rocks4/	Hilly to very steep (CD,2,3)
7411	Exchequer	3-16	Yellowish red/	Rocky silt loam/	Slightly acid/	Schistose4/ or altered basic igneous rock	Rolling to steep (1)
743	Auberry	30-60	Grayish brown/ brown	Coarse sandy loam/sandy clay loam	Slightly to moderately acid/ moderately to strongly acid	Granitic rock	Rolling to very steep (B,C,CD,2,3)
748	Sobrante	20-40	Reddish brown/ yellowish red	Silt loam/clay loam	Moderately acid/ slightly acid	Schistose to massive metamorphosed basic rock4/	Rolling to very steep (B,CD,2,3)
757	Sierra	30-60+	Brown/yellowish red to red	Coarse sandy loam/loam to clay loam	Moderately acid slightly acid	Strongly weathered granitic rock	Rolling to very steep (B,C,CD,D,2,3)
759	Kanaka	20-40+	Brown/very pale brown	Sandy loam/ heavy loam	Moderately to strongly acid/ strongly acid	Granitic rock	Gently sloping to very steep (B,C,CD,D,2,3)
771	Henneke	7-20	Brown/brown	Gravelly loam/very gravelly clay loam	Slightly acid/ neutral	Serpentinite	Steep to very steep (2)
775	Kidd	5-18	Pale brown/ light gray	Gravelly sandy loam/gravelly sandy loam	Moderately acid/ strongly acid	Rhyolitic rock	Hilly to very steep (2,3,4)
778	Huse	8-22	Reddish brown/ brown	Stony clay loam/ very stony loam	Neutral/ neutral	Peridotite	Gently sloping to steep (2,3)
779	Stonyford	12-28	Brown/dark reddish brown	Gravelly clay loam/gravelly clay loam	neutral/ moderately acid to neutral	Metamorphosed basic igneous rock4/	Hilly to very steep (CD,2,3)
781	Goulding	8-25	Brown/brown	Gravelly loam/ very gravelly loam	Slightly acid/ slightly acid	Metamorphosed basic igneous rock 4/	Steep to very steep (CD,D,2,3,4)

Table 1 (continued)

Soil series symbol	Soil series name	Depth range (inches)	Color of surface/subsoil	Texture of surface/subsoil	Reaction of surface/subsoil	Parent material	Relief and slope classes mapped[1]
784	Tollhouse	10-20	Dark grayish brown/	Coarse sandy loam/	Neutral to moderately acid/	Granitic rock	Steep to very steep (3)
811	Marpa	20-40	Brown/light brown	Very gravelly heavy loam/very gravelly clay loam	Slightly acid/ strongly acid	Shale and sandstone	Steep to very steep (1,2,3,4)
815	Josephine	30-60+	Brown to reddish brown/strong brown to yellowish red	Loam/clay loam	Moderately acid/ moderately to strongly acid	Sandstone and shale	Moderately steep to very steep (1,2,3)
815m	Josephine (schist)	30-60+	Brown to reddish brown/strong brown to yellowish red	Loam/clay loam	Moderately acid/ moderately to strongly acid	Metamorphosed sedimentary rock	Moderately steep to very steep (2,3)
816	Sites	36-60+	Brown to reddish brown/red	Loam/clay	Slightly to moderately acid/ strongly acid	Metamorphosed sedimentary rock	Rolling to steep (1,2,3)
820	Sheetiron	21-42	Dark grayish brown/pale brown	Gravelly light loam/gravelly heavy loam	Moderately acid/ strongly acid	Metamorphosed sedimentary rocks	Hilly to very steep (2,3)
824V	Fiddletown variant	20-60+	Dark grayish brown/brown or dark brown	Loam/clay loam	Slightly acid/ moderately acid	Metamorphosed sedimentary rock	Very steep (3)
8322	San Andreas	20-40	Brown/brown to yellowish brown	Fine sandy loam/ fine sandy loam	Moderately acid/ moderately acid	Mica schist[4]	Sloping to steep (B,C,D,2,3,4)
837	Millsholm	10-20	Brown/brown	Silt loam/silt clay loam	Slightly acid/ neutral	Sandstone and shale	Hilly to very steep (3)
837g	Millsholm (conglomerate)	8-30	Brown/brown	Gravelly loam/ gravelly loam	Slightly acid/ neutral	Conglomerate	Hilly to very steep (3)
871	Los Gatos	24-48	Brown/yellowish red or reddish brown	Light clay loam/ clay loam	Slightly acid/ moderately acid	Sandstone and shale	Hilly to very steep (2,3)
871L	Los Gatos (landslide)[5]	24-60+	Brown/yellowish red or reddish brown	Very gravelly loam/very gravelly clay loam	Slightly acid/ moderately acid	Sandstone and shale landslide debris	Gently sloping to very steep (1)
871m	Los Gatos (schist)	12-36	Brown/reddish brown	Gravelly loam/ gravelly clay loam	Slightly acid/ slightly acid	Metamorphosed sedimentary rocks	Gently sloping to very steep (2,3)
872	Maymen	4-20	Brown/light yellowish brown	Gravelly sandy loam/gravelly loam	Moderately acid/ strongly acid	Sandstone and shale	Rolling to very steep (1,2,3,4)
872m	Maymen (schist)	4-20	Pale brown/pale brown	Gravelly loam/ gravelly loam	Slightly acid/ moderately acid	Metamorphosed sedimentary rocks	Hilly to very steep (2,3)
926	Horseshoe	48-60+	Reddish brown to yellowish red/ yellowish red to red	Gravelly loam/ gravelly clay loam	Moderately acid/ very strongly to strongly acid	Weakly consolidated gravelly sediments	Nearly level to steep (C,CD,1,2)
941	Newville and Newtown[3]	40-60+	Brown/brown or pale brown	Gravelly loam/ clay	Slightly acid to neutral/strongly acid to slightly alkaline	Weakly consolidated gravelly sediments	Nearly level to steep (B,C,D)

(Footnotes follow on the next page)

Table 1—Footnotes

1/ Slope class symbol — Percent slope

Slope class symbol	Percent slope
A	0-3
B	3-8
C	8-15
D	15-30
AB	0-8
AC	0-15
CD	8-30
1	0-30
2	30-50
3	50-70
4	70 and greater

2/ Unclassified soils and miscellaneous land types mapped are:

Symbol	
200	Alluvial land (secondary soils on bottomland)
200 R	Alluvial land with 10- 50 percent surface rock
200 W	Wet alluvial land
400	Soils on terraces and benches
700(AK)	Colluvial land of granitic rock material
700(AK)R	Colluvial land of granitic rock material with 10- 50 percent rock outcrop
700(AP)	Mine dumps and pits of acid igneous rock material
700(AR)	Rockland (50-90 percent rockiness) of granitic rock material
700(AW)	River wash of acid igneous rock material
700(BK)	Colluvial land of basic igneous rock material
700(BK)R	Colluvial land of basic igneous rock material with 10- 50 percent rock outcrop or surface rock
700(BO)	Rock outcrop, basic igneous(90-100 percent rockiness).
700(BR)	Rockland, basic igneous (50-90 percent rockiness)
700(BR)K	Rockland, basic igneous (50-90 percent rockiness) with 10-50 percent colluvial soil material
700(BS)	Landslide, soil and rock of basic igneous origin
700(CK)	Colluvial land of sedimentary rock material
700(CK)O	Colluvial land of sedimentary rock material with 10-50 percent rock outcrop
700(CK)R	Colluvial land of sedimentary rock material with 10-50 percent rock outcrop or surface rock
700(CO)	Rock outcrop, sedimentary
700(CR)	Rockland, sedimentary (50-90 percent rockiness)
700(DH)	Dredge tailings
700(DK)	Colluvial land of mixed or undetermined rock material
700(DK)R	Colluvial land of mixed or undetermined rock material with 10-15 percent rock outcrop or surface rock
700(DP)	Mine dumps and pits of mixed or undetermined rock material
700(DR)	Rockland, mixed or undetermined rock material (50-90 percent rockiness)
700(DS)	Landslide, mixed or undetermined rock and soil material
700(DW)	Riverwash of mixed or undetermined rock material
700(MK)	Colluvial land of schistose rock and soil material
700(MO)	Rock outcrop, schistose (90-100 percent rockiness)

3/ The mapping units represented by these symbols have mixtures of the soil series designated. The second soil series named has been established since the time of field studies. The characteristics listed include those of both series as now defined.

4/ In this area rock may have been either igneous or sedimentary before metamorphism.

5/ The soil is formed on material that has undergone mass movement.

Table 2.--Selected behavior characteristics and productivity estimates for soil series and phases, unclassified soils, and miscellaneous land types

Map symbol	Soil series name	Soil phase symbols [1]	Permeability [2]	General drainage [3]	Erosion hazard [4]	Estimated suitabilities for: Timber production [5]	Extensive range use [6]
200	[7]		Rapid	Good [8]	Slight [9]	Unsuited to high	Medium
200R	[7]		Rapid	Good [8]	Moderate [9]	High	Medium
242	Greenfield	5	Moderately rapid	Good	Moderate [9]	Unsuited	Medium
400	[7]		Slow to moderate	Good	Slight [9]	Unsuited to high	Medium
522	Redding	2,2S,3	Slow	Good [10]	Moderate [9]	Unsuited	Low
700	[7]		Rapid to impermeable	Excessive	Slight to very high	Unsuited to medium	Very low
7117	Musick and Hoda soils	4,5	Slow	Good	High	Medium	Low
7117	Musick and Hoda soils	5E	Slow	Good	Very high	Medium	Very low
7118	Boomer	3,3S,4,4S	Moderate	Good	Moderate	Medium	Medium to low
7118	Boomer	3E	Moderate	Excessive	High [11]	Medium	Low [11]
7118m	Boomer (schist)	3,3S,4,4S	Moderately rapid	Good	High [11]	Medium	Low [11]
7121	Corbett	1E,1RE,2E	Rapid	Excessive	Very high	Unsuited to medium	Unsuited
7121	Corbett	2,2R,3R	Rapid	Excessive	High	Unsuited to medium	Unsuited
7121	Corbett	2R1,2S,3,3R1,4	Rapid	Excessive	High	Medium	Unsuited
7121	Corbett	2RE,3E,3RE	Rapid	Excessive	Very high	Medium	Unsuited
7125V2	Tish Tang variant 2	2,2S,3	Moderate	Good	Moderate	Unsuited to medium	Low to very low
7125V2	Tish Tang variant 2	2E	Moderate	Good	High [11]	Low	Very low [11]
7129	Chawanakee & Chaix	1E,2E,2RE	Moderately rapid	Excessive	Very high	Unsuited to medium	Unsuited
7129	Chawanakee & Chaix	2,2R,2R1,2S	Moderately rapid	Good to excessive	High	Low to medium	Low
7129	Chaix	3,4,4R1,5	Moderately rapid	Good to excessive	High	Medium	Low
7129	Chaix	3E,3RE,4E	Moderately rapid	Good to excessive	Very high	Medium	Unsuited
7135	Diamond Springs	2R,3,3S	Moderate	Good	Moderate to high	Medium	Low
7135	Diamond Springs	3E,3RE	Moderate	Good	High	Low to medium	Very low
7136	Behemotosh	2R,2R1,3R	Moderate	Good	High [11]	Low to medium	Low [11]
7136	Behemotosh	2S,3S	Moderate	Good	Moderate	Low to medium	Low
7136	Behemotosh	2SE	Moderate	Excessive	Very high [11]	Low	Very low [11]

Table 2 (continued)

Map symbol	Soil series name	Soil phase symbols 1/	Permeability	General drainage	Erosion hazard	Estimated suitabilities for: Timber production	Extensive range use
7136L	Behemotosh (landslide)	3S,5S	Moderate	Good	High 12/	Low to medium	Very low
7136V	Behemotosh variant	3,3S,4,4S	Moderate	Good	Moderate	Medium	Low
716	Holland & Hotaw	3,4,5	Moderate	Good	High	Medium	Medium to low
721	Modesty	1RE	Moderately rapid	Excessive	Very high	Unsuited	Unsuited
721	Modesty	2	Moderately rapid	Good to excessive	High	Low to medium	Low
721	Modesty	2E,2RE,2SE	Moderately rapid	Excessive	Very high	Unsuited to medium	Unsuited
721	Modesty	2R,2S	Moderately rapid	Good to excessive	High	Unsuited to medium	Low
721	Modesty	3,3S	Moderately rapid	Good to excessive	High	Medium	Low
726	Dubakella	3R1	Moderate	Good	Very high 11/	Medium	Low 11/
728	Neuns	2,2R,2S,3,3S	Moderate	Good to excessive	Moderate	Low to medium	Low to medium
728L	Neuns (landslide)	3S	Moderate	Good	High 11,12/	Medium	Low 11/
728m	Neuns (schist)	2,3,3S,5S	Moderate	Good	Moderate to high	Medium	Low
728m	Neuns (schist)	2S	Moderate	Good	Moderate to high	Low to medium	Low
741	Auburn	2,2S	Moderate	Good	Moderate	Unsuited	Medium
7411	Exchequer	1	Moderate	Good to excessive	Moderate 9/	Unsuited	Low
743	Auberry	2E	Moderate	Good	Very high 11/	Unsuited	Unsuited 11/
743	Auberry	3,4	Moderate	Good	High	Unsuited to questionable	Medium
748	Sobrante	3	Moderate	Good	Moderate	Unsuited	Medium
757	Sierra	3,3R,4,5	Moderate	Good	Moderate to high	Unsuited to questionable	Medium
757	Sierra	3E,4E	Moderate	Good	High to very high	Unsuited to questionable	Very low
759	Kanaka	1RE	Moderately rapid	Excessive	Very high 11/	Unsuited	Unsuited 11/
759	Kanaka	2,2R1,2S,3,3R1	Moderately rapid	Excessive	High	Unsuited	Medium
759	Kanaka	2R,3R	Moderately rapid	Excessive	High	Unsuited	Medium to low
771	Henneke	2R	Moderate	Good	Moderate	Unsuited	Low
775	Kidd	1R,1S	Moderately rapid	Excessive	High	Unsuited	Low
775	Kidd	1RE,1SE	Moderately rapid	Excessive	Very high 11/	Unsuited	Unsuited 11/
775	Kidd	2R	Moderately rapid	Good to excessive	High	Unsuited to low	Low

Table 2 (continued)

Map symbol	Soil series name	Soil phase symbols[1]	Permeability	General drainage	Erosion hazard	Estimated suitabilities for: Timber production	Extensive range use
775	Kidd	2S	Moderately rapid	Good to excessive	High	Unsuited to medium	Low
778	Huse	2R	Rapid	Good to excessive	Moderate	Low	Very low
779	Stonyford	2,2R,2S,3,3S	Moderate to slow	Good to excessive	Moderate to high	Unsuited	Very low
779	Stonyford	2SE,3SE	Moderate to slow	Good to excessive	High	Unsuited	Unsuited
781	Goulding	1R,1S,2R,2S	Moderate	Good to excessive	Moderate	Unsuited	Low to very low
781	Goulding	2RE,2SE	Moderate	Good to excessive	High[11]	Unsuited	Unsuited[11]
781	Goulding	3S	Moderate	Good	Moderate	Unsuited	Low to medium
784	Tollhouse	1E	Rapid	Excessive	Very high[11]	Unsuited	Unsuited [11]
811	Marpa	2R,2S,3S,4S	Moderate	Good	Moderate	Low to medium	Low to medium
815	Josephine	3,3S,4,4S,5	Moderate	Good	Moderate	Medium	Medium to low
815m	Josephine (schist)	3,3S	Moderate	Good	Moderate	Medium	Medium to low
816	Sites	3S,4S	Moderate	Good	Moderate	Medium	Medium
820	Sheetiron	2S	Moderate	Good to excessive	Moderate	Low to medium	Low
820	Sheetiron	3S	Moderate	Good	Moderate	Medium	Low
824V	Fiddletown variant	3S	Moderately rapid	Good	Moderate[11] to high	Unsuited to medium	Low[11]
8322	San Andreas	2	Moderate	Good	Moderate	Unsuited to questionable	Medium
8322	San Andreas	2R,2S	Moderate	Good to excessive	Moderate	Unsuited	Low to medium
837	Millsholm	2S	Moderate	Good	Moderate[11] to high	Unsuited	Medium to[11] low
837g	Millsholm (conglomerate)	2S	Moderate	Good	Moderate[11] to high	Unsuited	Medium to[11] low
871	Los Gatos	3S	Moderate	Good	Moderate	Unsuited	Low
871L	Los Gatos (landslide)	5S	Moderately rapid	Good	Slight[12]	Unsuited	Low
871m	Los Gatos (schist)	2S	Moderate	Good to excessive	Moderate to high	Unsuited	Very low
871m	Los Gatos (schist)	3	Moderate	Good	Moderate[11]	Unsuited	Low[11]
872	Maymen	1,1R,1S	Moderate to rapid	Excessive	High	Unsuited	Very low
872	Maymen	1E,1SE,2SE	Rapid	Excessive	High[11]	Unsuited	Unsuited [11]
872	Maymen	2,2R,2S	Moderate to rapid	Excessive	Moderate to high	Unsuited	Very low to low
872m	Maymen (schist)	1R,2R	Moderate to rapid	Excessive	High[11]	Unsuited	Very low[11]

Table 2 (continued)

Map symbol	Soil series name	Soil phase symbols1/	Permeability	General drainage	Erosion hazard	Estimated suitabilities for Timber production	Extensive range use
926	Horseshoe	5,5S	Moderate	Good	Moderate	Medium	Medium to low
926	Horseshoe	5SE	Moderate	Good	Moderate9/ to high	Medium	Low
941	Newville & Newtown	3S	Slow	Good	Moderate9/	Unsuited	Low
941	Newville & Newtown	3SE	Slow	Good	Moderate9/ to high	Unsuited	Low
941	Newville & Newtown	5S	Slow	Good	Moderate9/	Unsuited	Medium to low

1/ Phase symbols listed here are:

Symbol	Depth class	Depth (feet)	Symbol	Surface rock (percent)	Symbol	Stoniness	Symbol	Erosion
1	Very shallow	<1	R	10 - 50	S	Coarse fragments in the soil (gravel, cobbles, or stones) making up 20 percent or more of the soil's volume.	E	Severe
2	Shallow	1-2	R1	2 - 10				
3	Moderately shallow	2-3						
4	Moderately deep	3-4						
5	Deep	>4						

2/ Permeability: rate of water movement through the soil profile, based on the least permeable layer within the soil--slow, moderate, moderately rapid, rapid.

3/ General drainage: rate and extent of removal of water from the soil, either by runoff or by percolation--excessive, good (well-drained), imperfect, poor.

4/ Erosion hazard: probable susceptibility of a soil to erosion on a 30 to 50 percent slope (slope class 2) after significant disturbance of protective vegetative cover--slight, moderate, high, very high.

5/ Estimated suitability for commercial timber production: based on predominant site index determinations as related to soil and climatic characteristics regardless of current vegetative cover in an area. Relative terms are: unsuited = nontimberland; low = sites 1, 2; medium = sites 3, 4; high = site 5; questionable = conclusive evidence of suitability is lacking.

6/ Estimated suitability for extensive range use: based on observations of natural forage production, use experience over wide areas, and soil and climatic characteristics. Regardless of current vegetative cover, estimates are potential suitability applied to open areas, either natural or cleared, under extensive management (without seeding or fertilization) with average herbaceous cover conditions as related to soil type. Factors such as rockiness, topography, and erosion hazard are also considered. Estimates should not be interpreted as necessarily applying to suitability of soils for forage production under more intensive management involving seeding, fertilization or irrigation.
Relative terms are: unsuited, very low, low, medium, high, very high; unless otherwise indicated, they are applicable to soils of slope classes 1 and 2 (0 to 50 percent).

7/ Unclassified soils and miscellaneous land types mapped are listed in footnote 2 to table 1.

8/ Occasionally subject to flooding.

9/ For soils with slopes less than 30 percent.

10/ Soil rests abruptly on an impermeable iron-silica cemented hardpan.

11/ For soils with slopes steeper than 50 percent.

12/ May be subject to further movement, especially if disturbed or in years of above normal precipitation.

Table 3 --Plant species and miscellaneous elements mapped and observed including their growth habit, sprouting nature, and browse values

Map symbol	Common name	Scientific name	Growth habit	Sprout nature[1]	Browse value[2] H	C	S	G	D
A	White alder	Alnus rhombifolia	Tree	S	5	4-5	3-4	3-4	3-5
Aa[4]	Western service berry	Amelanchier pallida	Shrub	S	3-4	2-3	2-3	2	2-3
Aci	Vine maple	Acer circinatum	Shrub	S	4-5	3-4	3-4	3-4	2-4
Aec	California buckeye (Shrub)	Aesculus californica	Shrub	S	5	4	3-4	3-4	1-2
Af	Chamise	Adenostoma fasciculatum	Shrub	S	5	4-5	2-3	2-3	2-3
Am	Common manzanita	Arctostaphylos manzanita	Shrub	N	5	5	5	4-5	4-5
Amx[5]	Shingletown manzanita	Arctostaphylos manzanita wieslanderi	Shrub	N-S	5	5	5	4-5	4-5
An	Pinemat manzanita	Arctostaphylos nevadensis	Shrub	S	5	5	4-5	4-5	4-5
Ap	Greenleaf manzanita	Arctostaphylos patula	Shrub	S	5	5	4-5	4-5	3-4
App	Pine manzanita	Arctostaphylos patula platyphylla	Shrub	N	5	5	4-5	4-5	4-5
Aro[6,7]	Roof manzanita	Arctostaphylos roofii	Shrub	S	5	5	4	4-5	4-5
Ate[4]	Mountain alder	Alnus tenuifolia	Shrub	U	4-5	3-4	2-3	1-2	1-2
Av	Whiteleaf manzanita	Arctostaphylos viscida	Shrub	N	5	5	5	4-5	4-5
Avc	Balaklala manzanita	Arctostaphylos canescens x viscida	Shrub	N	5	5	5	4-5	4-5
B	California black oak	Quercus kelloggii	Tree	S	4-5	2-4	3-4	3-4	1-2
Ba[3]	--	--	--	--	--	--	--	--	--
C	Canyon live oak	Quercus chrysolepis	Tree	S	5	5	5	5	3-4
Cao[5]	Spice-bush	Calycanthus occidentalis	Shrub	S	5	5	5	5	5
Cb	Western mountain mahogany	Cercocarpus betuloides	Shrub	S	2-4	2	1-2	1-2	1
Cc	Buck brush	Ceanothus cuneatus	Shrub	N	5	4	2-3	2-3	3
Cco	Mountain whitethorn	Ceanothus cordulatus	Shrub	S, N	5	4	3	2-3	1-2
Cec	California redbud	Cercis occidentalis	Shrub	S	4-5	4-5	4	3-4	4-5
Chb[4]	Bloomer goldenbush	Haplopappus bloomeri	Shrub	U	5	5	4	4	4
Ci[8]	Deer brush	Ceanothus integerrimus	Shrub	S, N	3	2-3	1-2	1-2	1-2
Cla[4]	Pipe-stem clematis	Clematis lasiantha	Vine	--	--	--	--	--	--
Cle	Lemmon ceanothus	Ceanothus lemmonii	Shrub	S	5	4-5	3-4	3-4	3-4
Cn	Pacific dogwood	Cornus nuttallii	Shrub	S	5	5	3-4	3-4	3-4
Cos[5]	Miners dogwood	Cornus sessilis	Shrub	S	5	5	4-5	4-5	3-5
Cpj	Trinity squaw carpet	Ceanothus prostratus laxus	Shrub	U	5	5	4-5	3-4	2-4
Cpo	Squaw carpet	Ceanothus prostratus	Shrub	N	5	5	4-5	3-4	2-4
Cr	California hazelnut	Corylus cornuta californica	Shrub	S	4-5	4-5	4	3-4	3-4
Cs	Bush chinquapin	Chrysolepsis sempervirens	Shrub	S	5	5	4-5	4-5	4-5
Cu[3]	--	--	--	--	--	--	--	--	--
D	Douglas-fir	Pseudotsuga menziesii	Tree	N	5	5	4-5	4-5	4-5

Table 3 (continued)

Map symbol	Common name	Scientific name	Growth habit	Sprout nature 1/	Browse value 2/ H	C	S	G	D
D'	Blue oak	Quercus douglasii	Tree	S	4-5	4	3-4	3-4	1-2
Dp	Digger pine	Pinus sabiniana	Tree	N	5	5	5	5	5
Dr	Bush poppy	Dendromecon rigida	Shrub	S	5	4-5	3-4	3-4	3-4
Ec	California yerba santa	Eriodictyon californicum	Shrub	S	5	5	4-5	4-5	3-4
Fd 4/	Foothill ash	Fraxinus dipetala	Shrub	S	4-5	5	3-4	3	2-3
G	Oregon oak	Quercus garryana	Tree	S	5	4-5	4-5	4-5	2-3
Gf	Fremont silktassel	Garrya fremontii	Shrub	S	5	4-5	2-3	2-3	2-3
Gr 3/	--	--	--	--	--	--	--	--	--
H 4/	California buckeye	Aesculus californica	Tree	S	5	4	3-4	3-4	1-2
Hb 3/	--	--	--	--	--	--	--	--	--
Hp 4/	Klamath weed	Hypericum perforatum	Herb	S	5	4-5	3-5	3-4	3-4
I	Incense-cedar	Calocedrus decurrens	Tree	N	5	4-5	4-5	3-5	3-5
J	Jeffrey pine	Pinus jeffreyi	Tree	N	5	5	4-5	3-5	3-5
K	Knobcone pine	Pinus attenuata	Tree	N	5	5	5	5	5
Lcr	Big deervetch	Lotus crassifolius	Herb	U	5	5	5	5	4-5
Lde	Shrub tan oak	Lithocarpus densiflora echinoides	Shrub	S	5	5	5	4-5	1-2
Led 6/	Sierra-laurel	Leucothoe davisiae	Shrub						
Li 4/	Chaparral honeysuckle	Lonicera interrupta	Shrub	N	5	4-5	4	3-4	2-3
M	Madrone	Arbutus menziesii	Tree	S	5	4-5	4-5	4-5	3-5
M	Bigleaf maple	Acer macrophyllum	Tree	U	5	4-5	4	4	3-4
M' 5/	Oracle oak	Quercus morehus	Tree	S	4-5	2-4	3-4	3-4	1-2
Md 3/									
Ny 5/	Macnab cypress	Cupressus macnabiana	Tree	N	5	5	5	4-5	4-5
O	Oregon ash	Fraxinus latifolia							
Pa	Toyon (Christmas berry)	Heteromeles arbutifolia	Shrub	S	5	5	4-5	2-3	2-3
Pe	Bitter cherry	Prunus emarginata	Shrub	S	5	3	3-4	3	1-2
Phc 6/	Pacific ninebark	Physocarpus capitatus	shrub	U	4-5	4-5	3-4	4	4-5
Pl 4/	California mock orange	Philadelphus lewisii californicus	Shrub	S, N	5	4-5	3-4	3-4	3-4
Pom 4/	Sword fern	Polystichum munitum	Herb	S	5	5	5	4-5	3-4
Psu 4/	Sierra plum	Prunus subcordata	Shrub	S	5	2-3	2-3	2-3	1-2
Pta	Bracken	Pteridium aquilinum pubescens	Herb	S	5	5	5	5	5
Qc	Scrub canyon live oak	Quercus chrysolepis nana	Shrub	S	5	5	5	4	4
Qdu	Leather oak	Quercus durata	Shrub	S	5	5	4-5	4	3-5
Qgb	Brewer oak	Quercus garryana breweri	Shrub	S	5	4-5	4-5	4-5	3-4
Qk	Scrub black oak	Quercus kelloggii cibata	Shrub	S	4-5	2-4	3-4	3-4	1-2

Table 3 (continued)

Map symbol	Common name	Scientific name	Growth habit	Sprout nature 1/	Browse value 2/ H	C	S	G	D
Qv	Huckleberry oak	Quercus vaccinifolia	Shrub	S	5	4-5	4-5	4-5	3-4
Qw	Scrub interior live oak	Quercus wislizenii frutescens	Shrub	S	5	4	3-5	3-4	1-2
R 8/	California red fir	Abies magnifica	Tree	N	5	4-5	4-5	3-5	3-5
Rcc	Thickleaf coffeeberry	Rhamnus californica crassifolia	Shrub	S	5	3-4	2-4	2-4	2-4
Rci 4/	Hollyleaf redberry	Rhamnus crocea ilicifolia	Shrub	S	5	2-3	2-3	1-2	1-2
Rco 4/	Sierra coffeeberry	Rhamnus rubra obtusissima	Shrub	S	5	4-5	3-5	3-4	3-4
Rct	Chaparral coffeeberry	Rhamnus californica tomentella	Shrub	S	5	2-3	2-3	1-2	1-2
Rd	Poison oak	Rhus diversiloba	Shrub	S	2-3	3-4	3-4	3-4	2-3
Rho 5/	Western azalea	Rhododendron occidentale	Shrub	S	5	5	5	5	5
Rle 4/	Western raspberry	Rubus leucodermis	Shrub	S	5	5	4-5	3-5	3-4
Rox 4/	Rose	Rosa species	Shrub	S	4-5	4-5	3	2-3	2-3
Rp 4/	Western thimbleberry	Rubus parviflorus	Shrub	S	5	5	4	3-4	3-4
Rpu 5/	Cascara	Rhamnus purshiana	Shrub	S	5	4-5	4-5	3-4	3-4
Rr 4/	Sierra gooseberry	Ribes roezlii	Shrub	S, N	4-5	4	3	3	3-5
Rru 4/	Sierra coffeeberry	Rhamnus rubra	Shrub	S	5	4-5	3-5	3-4	3-4
Rt	Squaw bush	Rhus trilobata quinata	Shrub	S	4	4-5	4	4	3-4
Rx 4/	Rubus species	Rubus species	Shrub	S	5	5	4	3-4	3-4
S	Sugar pine	Pinus lambertiana	Tree	N	5	5	4-5	4-5	4-5
Sal 5/	Upright snowberry	Symphoricarpos rivularis	Shrub	U	4	3-4	3	2-3	3
Scu 4/	Spreading snowberry	Symphoricarpos acutus	Shrub	U	4	3-4	2-3	2-3	3-4
Sg 4/	Blue elderberry	Sambucus coerulea	Shrub	S	3	3-4	2-3	2	1-2
So	California storax	Styrax officinalis californica	Shrub	S	5	5	5	4-5	4-5
Sso	Creeping sage	Salvia sonomensis	Shrub	S	4-5	5	4-5	4	3-4
Sx	Willows	Salix species	S,T	S	5	4-5	3-4	3-4	2-3
Sxg 4/	Parish nightshade	Solanum parishii	H,S	U	--	--	--	--	--
T	Tan oak	Lithocarpus densiflora	Tree	S	5	5	5	5	5
Th 4/	Tree of heaven	Ailanthus altissima	Tree	--	--	--	--	--	--
U 5/	Pacific yew	Taxus brevifolia	Tree	U	5	5	5	5	5
Ui 3/	--	--	--	--	--	--	--	--	--
V	Valley oak	Quercus lobata	Tree	S	5	4	4-5	4-5	3-4
Vc	California wild grape	Vitis californica	Shrub	S	4-5	4-5	3-4	3-4	3-4
Vec 4/	California false-hellebore	Veratrum californicum	Herb	U	5	4-5	4-5	5	5
W	Interior live oak	Quercus wislizenii	Tree	S	5	4	3-5	3-4	3-4

Table 3 (continued)

Map symbol	Common name	Scientific name	Growth habit	Sprout nature 1/	Browse value 2/ H	C	S	G	D
Ŵ	White fir	Abies concolor	Tree	N	5	4-5	4-5	3-4	3-4
Whm 4/	Western whipplea	Whipplea modesta	Shrub						
Xs	Nuttall willow	Salix scouleriana	Shrub	S	4	3	2-3	2-3	3
Y	Ponderosa pine	Pinus ponderosa	Tree	N	5	5	4-5	4-5	4-5

1/ Sprout nature:

S =Sprouts after fire.

N = Normally will not sprout if top is fire killed.

S,N = Sprouts after fire in some cases and is completely killed in others.

U = Post-fire sprouting capacity unknown.

Note: Some species though killed by fire, will stump sprout after cutting in the absence of fire.

2/ Browse value over-all ratings, including sprouts after burning or cutting:

1 = Very high

2 = High

3 = Medium

4 = Low

5 = Very low

Kind of animal:

H = Horses; C = Cattle; S = Sheep; G = Goats; D = Deer.

3/ Miscellaneous vegetation and landscape elements mapped are:

Symbol:

Ba Rock, bare, or litter-covered ground, essentially devoid of vegetation.

Cu Cultivated or fallow field, natural haylands, and irrigated pastures.

Gr Grasses and other associated herbaceous plants, includes meadows.

Hb Herbaceous plants that are bushy in size and character of growth.

Md Wet meadow.

Mr Unidentified marshland herbs.

Ui Urban or industrial areas, frequently with no mappable soil due to industrial activity.

4/ Species not mapped but recorded on type-acre plots.

5/ Species observed but not mapped or recorded on type-acre plots.

6/ Species collected but not mapped or recorded on type-acre plots.

7/ See reference--Gankin, R. 1966. A new species of Arctostaphylos from Glenn County, California. Leaflet Western Botany 10:329-331.

8/ Includes the species and all its varieties.

Table 4.--Data on type-acre sampling plots

ot .	Location[1/] T	R	S	Aspect & percent slope	Soil symbol[2/]	Cover class[3/]	Date sampled	Soft chess[4/] Height (in.)	Stage	Ground cover[5/] H (percent)	L	B	RG	I	W	Woody species with available browse[6/]
QUADRANGLE 24D-1																
	33N	7W	13	SW-65	872/2S-3	2	22 Jul 64	-	-	(7/)	-	25	5	40	30	Af,Ap,Av,Cle,Rd,Cb,So
	33N	7W	13	S-55	872/1S-3	4	22 Jul 64	8	D	5	-	65	10	-	20	Af,Ec
	32N	7W	1	SW-50	779/2S-3	2	22 Jul 64	-	-	(7/)	(7/)	20	5	40	35	Af,Av,Pa,Ec,Rd,Qw,Cle,Li
	33N	6W	22	NE-42	7136V/4S-2	1	21 Jul 64	-	-	(7/)	75	15	(7/)	5	5	D,Cn,B,I,Lde,Y,Scu,Qc
	33N	6W	26	NE-30	7136L/3S-2	2	21 Jul 64	-	-	(7/)	5	15	(7/)	40	40	Qk,Ci,D,Y,Scu,Cn,Rct,Avc, B,Rd,Lde,M,Psu
	33N	6W	26	S-65	7136/2R3-3	3	21 Jul 64	-	-	(7/)	5	35	40	10	10	Av,C,I,D,Y,S,So,Rru,Pa
7	33N	6W	35	W-70	721/2S-3	1	13 Jul 64	-	-	(7/)	10	45	(7/)	10	35	B,Av,C,Cb,Rd,D,Y,Aec,Pa, So,Rru,M
	33N	6W	34	NE-55	7136/2S-3	1	22 Jul 64	-	-	(7/)	25	40	5	10	20	Av,C,B,Y,S,Lde,I,Rd,Cn, So,Aa,Ci
	33N	6W	35	S-65	721/2R1-3	3	13 Jul 64	-	-	(7/)	(7/)	45	20	15	20	Pa,Av,C,Cb,Pl,Rct,Ci,Rd, Qw,Aec,Dp,So,Li,Rco,M
	32N	6W	10	W-49	721/2E-2	3	22 Jul 64	-	-	15	10	45	(7/)	5	25	Av,B,Pa,Rd,C,So,Cle
1	32N	6W	13	SE-46	721/2RE-2	3	22 Jul 64	-	-	(7/)	15	50	10	5	20	Av,B,Aec,Sx,Pa,Cle
2	32N	6W	16	E-51	775/1S-3	2	22 Jul 64	-	-	(7/)	(7/)	30	5	35	30	Av,C,Pa,Rd,Dp,So,Ec,Cle
3	33N	6W	21	NW-60	811/3S-3	1	21 Jul 64	-	-	(7/)	(7/)	10	(7/)	60	30	B,Ci,Rd,D,Rr,M,Av,Scu,C, Ap,Cpo
4	33N	6W	28	NW-55	872/2S-3	1	21 Oct 66	-	-	(7/)	20	5	15	20	40	Qgb,Cb,Fd,Qk,Whm,Ci,Ap, Av,Qc,K,Rd,Li
5	33N	6W	14	SE-15	7136V/4-1	2	3 Apr 68	-	-	10	60	-	-	5	25	Cn,T,D,I,S,B,Y,Avc,Ap
QUADRANGLE 24D-2																
1	33N	8W	2	N-68	820/3S-3	1	29 Jul 64	-	-	(7/)	10	-	5	60	25	Cr,Lde,C,M,D,Xs,Rox,Scu
2	33N	8W	12	SW-60	7125V2/3-3	2	29 Jul 64	-	-	5	85	5	-	-	5	B,D,Cr,Scu,Lde,Ci,Rox,S, Y,Pe
3	33N	7W	16	W-55	7125V2/3-3	2	30 Jul 64	9	D	15	25	45	-	(7/)	15	Qgb,Qw,Cb,Rd,Cla,Ci,Aec
4	33N	8W	26	N-44	815/5-2	3	29 Jul 64	-	-	15	50	30	-	(7/)	5	D,Scu,B,C,Lde,Rr,Cr
5	33N	7W	29	SW-66	837/2S-3	3	29 Jul 64	10	D	5	(7/)	70	10	-	5	Cc,Af,Rd,Qw,D',Ec,C[illegible],Av, Sxg
6	33N	7W	31	S-55	815/5-3	3	24 Jul 64	12	D	15	35	45	-	-	5	Rt,Rd,Aec,D',Cec,Li,Ci,C, Sg,G
7	32N	7W	3	SE-32	926/5S-2	1	24 Jul 64	-	-	5	10	25	-	30	30	Av,C,Rt,Rd,Li,Cc,Pa,B, W,Cec,Cb,D',Th

Table 4 (continued)

Plot No.	Location[1/] T	R	S	Aspect & percent slope	Soil symbol[2/]	Cover class[3/]	Date sampled	Soft chess[4/] Height	Stage	Ground cover[5/] H	L	B	RG	I	W	Woody species with available browse[6/]
								(in.)		(percent)						
QUADRANGLE 24D-2																
8	32N	7W	6	W-55	7117/5-3	2	24 Jul 64	-	-	5	20	65	-	(7/)	10	Rd,Cb,Ci,Cec,Af,B,Aec,C, Cle,Av,Qw,Ap,Pau,Scu,Li
9	32N	8W	11	NW-15	716/5-1	2	30 Jul 64	-	-	20	40	35	-	-	5	D,Y,B,Scu,S,C,Li,Rox
10	32N	8W	12	SE-80	7129/2-4	3	8 Jul 65	-	-	5	20	55	-	10	20	C,M,Y,B,Cle,Rd,Ci,S,D,Av
11	32N	8W	12	NE-32	7158/3-2	2	30 Jul 64	-	-	(7/)	85	10	-	(7/)	5	Rd,B,D,Y,C,S,Ci,Cr,Ate, Lde,Cn,Cle
12	32N	8W	13	NE-66	7121/2-3	1	28 Jul 64	-	-	(7/)	5	5	-	80	10	Lde,Cn,C,D,M,B,Cb,Rox, Rp,S,Rr,Scu
13	32N	7W	17	N-20	716/5-1	1	28 Jul 64	-	-	5	20	70	-	(7/)	5	Rd,Cle,D,B,Cec,C,Y,S,T, Ci
14	33N	7W	7	NE-65	7125V2/3-3	2	28 Apr 68	-	-	10	50	5	5	15	15	Qk,Cr,Aa,Rox,Scu,Ci,C, D,M,T,Y,B,Cn,Rp,Rd,Rr
QUADRANGLE 24D-3																
1	32N	8W	24	NE-15	7121/2-1	2	28 Jul 64	-	-	10	-	70	-	-	20	Cpj, Chb,Ap
2	32M	7W	30	N-6	7121/2-1	2	28 Jul 64	-	-	5	10	25	-	30	30	Lde,Cpj,Ap,I,D,S,Cn,Ŵ, Y,Rr,Ate
3	32N	7W	32	E-20	7121/5-1	2	28 Jul 64	-	-	10	10	75	-	(7/)	5	Lde,S,Ŵ,Cs,App,Led
4	31N	7W	29	S-15	716/5-1	2	23 Jul 64	-	-	(7/)	15	50	-	10	25	Av,Am,Cle,Rd,Y,B,D,C,Ci
5	31N	7W	28	N-25	7129/5-1	2	29 Jul 64	-	-	(7/)	5	20	-	35	40	Av,Cle,Rd,Rox,Ci,Am,Ec,B Y,C
6	31N	7W	30	NE-34	7117/5-2	2	23 Jul 64	-	-	10	20	55	-	(7/)	15	Av,Am,Cle,C,S,Y,B,Rd,Rox Ci,Cn
7	31N	7W	33	S-16	757/2E-1	2	29 Jul 64	-	-	(7/)	-	20	-	30	50	Af,Ap,Av,Cle,Qw,Ef,B,Qgb Rd
8	31N	7W	29	W-25	7117/2E-1	2	23 Jul 64	-	-	(7/)	10	20	-	35	40	Cle,B,Av,Ap,Qgb,C,Y,Rox, Ec
9	31N	7W	30	NE-55	7129/3-3	3	2 Jul 60	-	-	5	70	5	-	10	10	Rd,C,B,D,M
10	31N	7W	31	SW-33	7129/3E2-2	2	23 Jul 64	-	-	10	5	25	-	15	40	Av,Am,Cle,Y,I,M,Rd,D,Ci, Rox,B,C
QUADRANGLE 24D-4																
1	31N	6W	32	S-8	757/4-C	3	3 May 72	20	F	20	59	16	-	-	5	Am,D',Av,Rd,W,Li,V,Sg, Cc,Dp
2	32N	6W	23	W-40	721/2-2	2	27 Jul 64	-	-	(7/)	5	20	10	40	25	Av,Pa,So,B,C,Rd,Cle,Ci
3	32N	6W	27	SW-30	775/2S-2	1	27 Jul 64	-	-	(7/)	30	30	5	10	25	Av,Rd,Cle,B,So,Ec,C,Y, Qw,Pa,Li,Px
4	32N	6W	21	W-35	781/2S-2	1	27 Jul 64	-	-	(7/)	5	15	10	50	20	Av,Qgb,Qw,So,Rd,Dp,Af, Pa,Ec,Cec,Rci,Li,Scu
5	32N	6W	28	NE-23	7118/4-1	2	25 Jun 64	-	-	5	60	10	-	(7/)	25	Av,Pa,Rd,B,Rox,Y,Qc,D, Cle,S

ble 4 (continued)

lot o.	Location 1/ T	R	S	Aspect & percent slope	Soil symbol 2/	Cover class 3/	Date sampled	Soft chess 4/ Height	Stage	Ground cover 5/ H	L	B	RG	I	W	Woody species with available browse 6/
								(in.)		--------(percent)---------						
								QUADRANGLE 24D-4								
6	32N	6W	29	NW-60	728 / 2S-3	2	27 Jul 64	-	-	5	35	25	-	15	20	B,C,Av,Rd,D,Y,Cn,Lde,Rox, Cle,K,S,Rru
7	31N	6W	2	SW-50	721 / 2S-3	3	20 Apr 72	-	-	5	10	55	15	-	15	Pa,Av,Rd,Cle,W,So,B,Dp, Li,Rct,Cb,Aec

/ Plots shown on the map by circled numbers in the Township (T), Range (R), and Section (S) indicated.

/ Soil series and phases, see Tables 1 and 2 for key. Detailed soil profile descriptions for these sites are on file at the Pacific Southwest Forest and Range Exp. Sta., Berkeley.

/ Area covered by crowns of all woody plants:

Symbol	Cover Class	Ground Covered (Percent)
1	Dense	> 80
2	Semidense	50-80
3	Open	20-50
4	Very Open	5-20
5	Extremely Open	< 5

/ Mean maximum height and stage of maturity of soft chess (Bromus mollis):

V = Vegetative stage (plant not yet flowering)
F = Flowering stage (plant has seed stalk and is still green)
D = Dry stage (plant is dead)

/ Ground space covered or occupied by these vegetation and landscape units below a reference plane 4.5 feet above the ground:

H = Herbage—all herbaceous plant material of the current growing season.
L = Litter--dead plant material on the ground exclusive of heavy woody material.
B = Bare soil--particles less than 2 mm.
RG = Rock and gravel--surface coarse fragments greater than 2 mm and bedrock.
I = Inaccessible--space that grazing animals physically cannot occupy owing to presence of tree stems, logging debris, tall and dense brush, and other obstructions.
W = Woody vegetation available for browsing--small twigs and foliage of all woody plants regardless of palatability less than 4.5 feet tall and accessible to grazing animals.

Browse species are listed in last column of this table. Herbaceous and all woody species are listed in Table 5.

6/ Listed in decreasing order of abundance. See Table 3 for key to species symbols and browse values.

7/ Unit is present but too scarce to measure (usually less than 5 percent).

Table 5.--Plant species on type-acre sampling plots [1/]

Scientific name	Common name	24D-1	24D-2	24D-3	24D-4
		7.5-minute quadrangle numbers			
		Plot numbers where found			
ANNUAL GRASSES:					
Aira caryophyllea	Silver hairgrass	10,11,12.	6,7,9,10,13.	4,5,6,8,10.	1,2,3,4,7.
Avena barbata	Slender wild oats		3,5,6,8.		1,3.
Avena fatua	Common wild oats				1.
Briza minor	Little quakinggrass				3.
Bromus carinatus	California brome	13.	6,8,9,10,13.	9,10.	
Bromus commutatus	Hairy chess				1.
Bromus madritensis	Spanish brome		7.		1,4,7.
Bromus mollis	Soft chess	2.	3,5,6.		1,4.
Bromus racemosus	Smooth soft chess		6.		1.
Bromus rigidus	Ripgut		3,5,6,8.	9,10.	1.
Bromus rubens	Red brome	2,9.	5,7.	7.	7.
Bromus tectorum	Cheatgrass, Downy brome	2.	3,5,7,9,10,12.	1.	
Cynosurus echinatus	Annual dogtail				1.
Festuca spp.	Annual fescue	14.		9.	
Festuca bromoides	European foxtail fescue	2.	5.	5.	1,4.
Festuca confusa	Confusing fescue		10.		
Festuca megalura	Foxtail fescue		13.	5.	1, 7.
Festuca microstachys	Pubescent reflex fescue	9.	8,13.	4,6.	3.
Festuca myuros	False foxtail fescue	1,2,7,9,10,11, 12,13.	3,5,6,7,8,13.	4,5,6,7,8,10.	2,3,4,5.
Festuca pacifica	Pacific fescue		6.	6,10.	7.
Festuca reflexa	Reflex fescue	7,12.	3,9,10.		3.
Gastridium ventricosum	Nitgrass	2,9.	7,13.	4,10.	3,4.
Hordeum leporinum	Foxtail, mouse barley				1.
Lolium multiflorum	Italian ryegrass				1.
PERENNIAL GRASSES AND GRASS-LIKE PLANTS:					
Agropyron parishii laeve	Parish wheatgrass		6,10.		
Agropyron spicatum	Bluebunch wheatgrass		9.		
Agrostis diegoensis	Leafy redtop	7.			
Agrostis exarata	Spike redtop	10.		6,10.	3,5,6.
Bromus laevipes	Woodland brome		3,8,13.		5.
Bromus orcuttianus	Orcutt brome	4,13.	12.	1,2,3.	
Carex spp.	Sedge	5,6,14.	4.	1,2,3.	
Carex multicaulis	Many-stem sedge	4,5,7,13.	2,9,10,11,14.	2,5,9.	5.
Elymus glaucus glaucus	Blue wild rye		2,4,6,7,8,9.	5,6,9,10.	
Elymus glaucus jepsonii	Jepson wild rye	4,13.			
Festuca californica	California fescue	4,5,8.	2,4,9,12,13.		
Festuca occidentalis	Western fescue	7.	4,9,11,12,13, 14.	9.	5.
Luzula comosa	Common wood rush		10.		
Luzula subsessilis	Foothill wood rush	10.	4,8,9,13.	4,6.	1,5,6.
Melica aristata	Awned melic		10,11,12.	2.	
Melica geyeri	Geyer oniongrass		4.		
Melica harfordii	Harford melic		8,13.		
Poa pratensis	Kentucky bluegrass	13.			1.
Poa scabrella	Pine bluegrass	7.	3,6,7,8,9, 10,11,13.	9.	
Sitanion hystrix californicum	Squirreltail	9,13.	5,7.	1,2,4.	4,5.
Stipa californica	California stipa			1,2.	
Stipa lemmonii	Lemmon stipa	7,13.	5,6,13.	4,6,8,10.	3,5.
Stipa stillmanii	Stillman stipa			2,3.	
Trisetum cernuum canescens	Tall trisetum	4.	11.		

Table 5 (continued)

Scientific name	Common name	24D-1	24D-2	24D-3	24D-4
		7.5-minute quadrangle numbers			
		Plot numbers where found			
ANNUAL FORBS:					
Allophyllum divaricatum		2.			
Calycadenia truncata scabrella		9.	6.		
Centaurea melitensis	Napa star thistle	2.	5.		
Centaurea solstitialis	Yellow star thistle				1.
Cerastium viscosum	Mouse-ear chickweed		3.		1.
Cirsium pastoris	Snowy thistle		8,10.		
Cirsium proteanum	Venus thistle	2.	5.		
Clarkia sp.	Farewell-to-spring				1.
Clarkia rhomboidea	Forest clarkia		3,10,11.		7.
Collomia sp.	Collomia		7.		
Crucianella angustifolia	Crucianella		6.		
Cryptantha sp.	Cryptantha		8,10.	1.	
Daucus pusillus	Rattlesnake weed		3,5,6.		1,4,7.
Epilobium minutum	Slender annual fireweed	1,7.	7,10,12.		
Eriogonum vimineum	Wicker buckwheat	2.	10.		
Erodium cicutarium	Red-stem filaree		6.		
Erodium obtusiplicatum	Foothill Filaree		5.		
Euphorbia spathulata	Spurge		6.		
Evax acaulis					7.
Filago gallica	Filago	2,9,11,12.		4,7.	1,2.
Galium aparine	Goosegrass		4,9,10,12.		1.
Galium divaricatum	Lamark bedstraw		6.		
Galium parisiense	Wall bedstraw				1.
Gayophytum diffusum diffusum	Gayophytum		12.	1,2,3.	
Geranium dissectum	Common wild geranium				1.
Gilia capitata pedemontana	Blue field gilia	9.	10.	1.	
Githopsis specularioides	Common blue-cup		10.		
Hypochoeris glabra	Smooth catsear				7.
Lactuca serriola	Prickly lettuce				1.
Lessingia nemaclada		9.	5,6,8.		
Linanthus bicolor	Linanthus		6.		1.
Linanthus ciliatus	Whisker linanthus		5.	1.	
Lotus micranthus	Small-flower lotus		3,5,7,10.	4.	1,2,7.
Lotus purshianus	Spanish clover	1,11,12.			
Lotus subpinnatus	Calf lotus		7,8.	10.	7.
Lupinus sp.	Annual Lupine		5.		
Lupinus bicolor microphyllus	Bicolor annual lupine				1.
Lupinus vallicola apricus	Foothill lupine				7.
Madia elegans	Common madia		10.		
Madia exigua	Little tarweed		3,6,10.	8,10.	
Madia gracilis	Gumweed madia	2.	2,3,5,6,8, 9,10,13.	1,10.	
Medicago hispida	Bur medic, bur clover				1.
Micropus californicus	Micropus		5.		1.
Microsteris gracilis	Microsteris		2,4,10.		
Montia perfoliata	Miners lettuce		2,3,12.	10.	1.
Moss and moss-like plants		1,3,9,10.	1,8,12.	5,7,8,10.	1,2,3,6,7.
Nemophila pedunculata	Meadow nemophila				1.
Plagiobothrys sp.	Popcorn flower				7.
Silene gallica	Windmill pink		5.		
Sisymbrium officinale	Hedge mustard				1.
Stellaria media	Common checkweed				1.
Stephanomeria virgata	Tall stephanomeria	2.	3,5,6.		
Streptanthus tortuosus		6.			
Thysanocarpus curvipes elegans	Lace pod				7.
Torillis arvensis	Field hedge parsley				1.

Table 5 (continued)

Scientific name	Common name	24D-1	24D-2	24D-3	24D-4
		7.5-minute quadrangle numbers			
		Plot numbers where found			
ANNUAL FORBS: (continued)					
Torilis nodosa	Knotted hedge parsley				1.
Trifolium bifidum	Pinole clover		6.		
Trifolium ciliolatum	Tree clover		5,6.		1.
Trifolium dubium	Shamrock clover				1.
Trifolium hirtum	Rose clover		3.		1.
Trifolium microcephalum	Maiden clover		5,6.		1,7.
Trifolium olivaceum columbinum	Dove clover		5.		
Trifolium tridentatum	Tomcat clover				7.
Tunica prolifera	Tunica				1.
Vivia angustifolia	Common vetch				1.
PERENNIAL FORBS:					
Achillea borealis californica	Common yarrow				5.
Achillea lanulosa lanulosa	Mountain yarrow		2,6,7,8,9, 10,13.	9.	
Adenocaulon bicolor	Trail plant		4,14.		
Agoseris grandiflora	Grand mountain dandelion		3,6,8,9.		3.
Agoseris retrorsa	Spear-leaf mountain dandelion			6.	
Allium sp.	Onion		3.		
Apocynum pumilum	Mountain hemp	4,5,8,10.	9,10,13.	2,4,8.	5,6.
Aquilegia formosa	Columbine		14.		
Aralia californica			12.		
Arnica discoidea eradiata			1,4.		
Arnica venosa					6.
Asarum hartwegii	Hartweg wild ginger	4.	1,14.		
Asclepias cordifolia	Purple milkweed		10.		
Aster oregonensis		11.			
Balsamorhiza deltoidea	Deltoid balsamroot		10.		
Brodiaea spp.	Brodiaea	10.	4.	8.	6.
Brodiaea congesta	Ookow		8.		
Brodiaea ida-maia	Firecracker flower		6.	9.	
Brodiaea lutea analina	Golden brodiaea			6,9.	
Brodiaea pulchella	Wild-hyacinth		6.		1,5.
Calochortus spp.	Mariposa Lily		2.	6,10.	
Calochortus tolmiei	Tolmie star-tulip				7.
Calystegia polymorpha	Modoc morning-glory	4,7.	2,8,9,13.		3,5,6.
Campanula prenanthoides	California harebell	4,5.	4,11,12,14.		6.
Castilleja sp.	Paint brush				6.
Chlorogalum pomeridianum	Soap plant			6,10.	7.
Comandra umbellata californica	Bastard toad-flax	8.	2.		2,6.
Cynoglossum grande	Western houndstongue		2,4.		
Cynoglossum occidentale	Houndstongue				6.
Delphinium sp.	Larkspur		2,3.		
Dentaria sp.			4.		
Disporum hookeri trachyandrum	Sierra fairy bells		4.		
Dodecatheon sp.	Shooting stars		2,4.	9.	6,7.
Erigeron inornatus	California rayless daisy		8,10.		
Eriogonum nudum pubiflorum		13.	5,10.	1.	1,7.
Eriogonum umbellatum umbellatum	Sulfur buckwheat			1.	
Eriophyllum lanatum grandiflorum	Common Woolly-sunflower	9.	5,8,10.	10.	3,4,7.
Erythronium sp.		4.			
Frasera albicaulis nitida	Shining frasera	5,8,10.	9,13.	2,4,8.	6.
Fritillaria sp.	Fritillary		2.		
Galium sp.		14.	14.		
Galium bolanderi	Bolander galium		2,10,11,13.	4,6.	3,4,5,6.
Galium nuttallii tenue	Climbing galium	5,9,10,12.	3,5,6,7,8,10.	5,9,10.	2,3,7.
Gnaphalium sp.	Everlasting	2,12.	9,13.		7.
Habenaria elegans				6.	

Scientific name	Common name	7.5-minute quadrangle numbers: 24D-1	24D-2	24D-3	24D-4
		Plot numbers where found			
PERENNIAL FORBS: (continued)					
Helianthella californica nevadensis	Sierra helianthella	5,8,10,12.	2,4,9,11.	4,6,8.	5,6.
Hieracium albiflorum	White-flower hawkweed	6,7,8.	2,4,9,12,14.	6,10.	5,6.
Horkelia tridentata	Three-tooth horkelia				3.
Hypericum concinnum	Goldwire	7,9,10,11,12.		4,5,6,8.	2,3,4,5,6.
Hypericum perforatum	Klamath weed		7.	10.	1,3,5.
Iris hartwegii	Iris	4.			
Iris tenuissima	Iris	4,5,6,8,10,15.	2,4,9,10,11, 12,13,14.	1,2,3,5,6,9, 10.	6.
Iris tenuissima purdyiformis	Iris	7.			5.
Kelloggia galioides	Kelloggia			1,2.	
Lathyrus sulphureus	Sulfur pea	2,4,8,9,10,13.	4,6.		
Lithospermum californicum	Shasta puccoon				5,6.
Lomatium utriculatum	Common lomatium		8.		
Lotus crassifolius	Big deervetch		9,10.	2,3.	
Lupinus spp.	Lupine	5,7,15.	2,4,9.	1,4,10.	6.
Lupinus andersonii	Anderson lupine			3.	
Lupinus latifolius	Lupine		3,5.		
Marah sp.	Wild cucumber	14.	6,8.		
Monardella odoratissima	Mountain monardella	9.	13.	4,6,10.	
Monardella villosa sheltonii	Monardella		10.		6.
Onychium densum	Cliff-brake				7.
Osmorhiza chilensis	Mountain sweet-cicely	4,7.	2,4,8,9,11, 13,14.	9.	5,6.
Pedicularis densiflora	Indian warrior	8,15.	2,9.		6.
Pellaea mucronata	Birdsfoot fern	9,12.			
Perideridia sp.			9.		
Phacelia sp.	Phacelia	2.	5.	1.	
Pityrogramma triangularis	Goldenback fern				3,7.
Polygala cornuta	Sierra milkwort	5,10.	11,14.	2.	2.
Polystichum munitum	Sword fern	6,7,13.	1,14.		6.
Potentilla glandulosa	Common cinquefoil		8.		
Pteridium aquilinum pubescens	Bracken fern	4,7,8,15.	2,4,9,10,11, 14.	2,4,5,6,9.	5,6.
Pyrola picta picta	White-vein shinleaf	15.			
Ranunculus occidentalis eisenii	Western buttercup		6.	10.	1.
Rumex acetosella	Sheep-sorrel				1.
Salvia sonomensis	Creeping sage	1,3.			4.
Sanicula bipinnatifida	Purple Sanicle		6,8,9,10.	9,10.	4,5.
Senecio aronicoides	California groundsel		12.		
Silene californica	Calif. scarlet campion	7.	11.		6.
Smilacina racemosa amplexicaulis	Fat solomon		1,4,12,14.		
Thermopsis gracilis	Slender false-lupine	15.	2,4.		
Trientalis latifolia	Star flower	5,15.	1,12,14.		2,5,6.
Veratrum californicum	Western false hellebore		4,14.		
Vicia americana oregana	American vetch			4.	
Vicia californica	California vetch		2,4,6,9,14.	5,6.	
Viola spp.	Violet	15.	2.	5.	3.
Viola lobata lobata	Pine violet	4.	14.		
Viola lobata integrifolia	Pine violet	4.			
Viola purpurea	Mountain violet		10.		
Viola sheltonii	Shelton violet		12.		
Wyethia angustifolia	Narrow-leaf mule ears	10.	5,11.	4.	6.
Zigadenus fremontii	Star-lily				7.
TREES AND SHRUBS:					
Abies concolor	White fir			2,3.	

Table 5 (continued)

Scientific name	Common name	7.5-minute quadrangle numbers 24D-1	24D-2	24D-3	24D-4
		Plot numbers where found			
TREES AND SHRUBS: (continued)					
Acer macrophyllum	Bigleaf maple	5,7,9,13.	1,10,12,14.	9.	
Adenostoma fasciculatum	Chamise	1,2,3.	5,8.	7.	4.
Aesculus californica	Shrub california buckeye	7,9,11.	3,6,8.		7.
Ailanthus altissima	Tree of heaven		7.		
Alnus rhombifolia	White alder	(3/)	(3/)	(3/)	(3/)
Alnus tenuifolia	Mountain alder		11.	2.	
Amelanchier pallida	Western serviceberry	8.	14.		
Arbutus menziesii	Madrone			10.	
Arctostaphylos canescens x viscida	Balaklala manzanita	5,15.			
Arctostaphylos manzanita manzanita	Common manzanita			4,5,6,10.	1.
Arctostaphylos manzanita wieslanderi	Shingletown manzanita	(4/)			
Arctostaphylos nevadensis	Pinemat manzanita			(3/)	
Arctostaphylos patula patula	Greenleaf manzanita	1,13,14,15.	8.	1,2,7,8.	
Arctostaphylos patula platyphylla	Pine manzanita			3.	
Arctostaphylos roofii	Roof manzanita		(5/)		
Arctostaphylos viscida	Whiteleaf manzanita	1,3,6,7,8, 9,10,11,12, 13,14.	5,7,8,10.	4,5,6,7,8,10.	1,2,3,4,5,6,7.
Calocedrus decurrens	Incense-cedar	4,6,8,15.		1,2,3,10.	
Calycanthus occidentalis	Spice-bush		(4/)		(4/)
Ceanothus cordulatus	Mountain whitethorn			(3/)	
Ceanothus cuneatus	Wedgeleaf ceanothus		5,7.		1.
Ceanothus integerrimus[2/]	Deerbrush	5,8,9,13,14.	2,3,6,8,10, 11,13,14.	4,5,6,10.	2.
Ceanothus lemmonii	Lemmon ceanothus	1,3,10,11,12.	8,10,11,13.	4,5,6,7,8,10.	2,3,5,6,7.
Ceanothus prostratus laxus	Upright squaw carpet			1,2.	
Ceanothus prostratus prostratus	Squaw carpet	13.			
Cercis occidentalis	California redbud		5,6,7,8,13.		4.
Cercocarpus betuloides	Birchleaf mountain mohogany	1,7,9,14.	3,7,8.		7.
Chrysolepis sempervirens	Bush chinquapin			3.	
Clematis lasiantha	Pipe-stem clematis		3.		
Cornus nuttallii	Pacific dogwood	4,5,8,15.	11,12,14.	2,6.	6.
Cornus sessilis	Miners dogwood				(4/)
Corylus cornuta californica	California hazelnut		1,2,4,11,12,14.		
Cupressus macnabiana	Macnab cypress	(4/)			
Dendromecon rigida	Bush poppy		(3/)		
Eriodictyon californicum	California yerba santa	2,3,12.	5.	5,7,8.	3,4.
Fraxinus dipetala	Foothill ash	14.			
Fraxinus latifolia	Oregon ash	(3/)			
Garrya fremontii	Fremont silktassel	(3/)	(3/)		
Haplopappus bloomeri	Bloomer goldenbush			1.	
Heteromeles arbutifolia	Toyon, christmas berry	3,6,7,9,10, 11,12.	7.		2,3,4,5,7.
Leucothoe davisiae	Sierra-laurel			3.	
Lithocarpus densiflora densiflora	Tan-oak	15.	13,14.		
Lithocarpus densiflora echinoides	Shrub tan-oak	4,5,8.	1,2,4,11,12.	2,3.	6.
Lonicera interrupta	Chaparral honeysuckle	3,9,14.	6,7,8,9.		1,3,4,7.
Penstemon breviflorus glabrisepalus	Penstemon				3.
Philadelphus lewisii californicus	California mock orange	9.			
Physocarpus capitatus	Pacific nine bark	(5/)	(4/)		
Pinus attenuata	Knobcone pine	5,6,8,11,14.	7.		3,6,7.
Pinus lambertiana	Sugar pine	4,6,8,13,15.	2,9,10,11,12, 13.	2,3,6.	5,6.
Pinus ponderosa	Ponderosa pine	4,5,6,7,8, 11,13,15.	2,4,6,7,8,9, 10,11,13,14.	1,2,3,4,5,6, 8,9,10.	3,5,6,7.

Table 5 (continued)

Scientific name	Common name	7.5-minute quadrangle numbers 24D-1	24D-2	24D-3	24D-4
		Plot numbers where found			
TREES AND SHRUBS: (continued)					
Pinus sabiniana	Digger Pine	9,12.	3,5,7,8.		1,2,4,7.
Prunus emarginata	Bitter cherry		2.		
Prunus subcordata	Sierra plum	5.	8.		
Pseudotsuga menziesii	Douglas-fir	4,5,6,7,8, 13,15.	1,2,4,8,9,10, 11,12,13,14.	2,4,9,10	5,6.
Quercus chrysolepis chrysolepis	Canyon live oak	6,7,8,9,10,	1,4,6,7,8,9, 12,13.	4,5,6,8,9,10. 10,11,12,13,14.	2,3,6.
Quercus chrysolepis nana	Shrub canyon live oak	4,14.			5.
Quercus douglasii	Blue oak		5,6,7.		1.
Quercus durata	Leather oak			(3/)	
Quercus garryana breweri	Brewer oak	14.	3.	7,8.	4.
Quercus garryana garryana	Oregon oak, garry oak		6.		
Quercus kelloggii cibata	Shrub Calif. black oak	5,14.	14.		
Quercus kelloggii kelloggii	California black oak	4,5,7,8,10, 11,13,15.	2,4,6,7,8,9, 10,11,12,13,14.	4,5,6,7,8,9, 10.	2,3,5,6,7.
Quercus lobata	Valley oak				1.
Quercus morehus	Oracle oak	(4/)			
Quercus vaccinifolia	Huckleberry oak			(3/)	
Quercus wislizenii frutescens	Shrub interior live oak	3,9.	3,5,8.	7.	3,4.
Quercus wislizenii wislizenii	Interior live oak		7.		1,7.
Rhamnus californica crassifolia	Thick-leaf coffeeberry			(3/)	
Rhamnus californica tomentella	Chaparral coffeeberry	5,9.			7.
Rhamnus crocea ilicifolia	Hollyleaf redberry				4.
Rhamnus purshiana	Cascara sagrada	(4/)			
Rhamnus rubra obtusissima	Sierra coffeeberry	9.			
Rhamnus rubra rubra	Sierra coffeeberry	6,7.			6.
Rhododendron occidentale	Western azalea				(4/)
Rhus diversiloba	Poison-oak	1,3,5,7,8,9, 10,12,13,14.	3,5,6,7,8,10, 11,13,14.	4,5,6,7,9,10.	1,2,3,4,5,6,7.
Rhus trilobata quinata	Common squaw bush		6,7.		
Ribes roezlii	Sierra gooseberry	13.	4,12,14.	2.	
Rosa sp.	Rose		1,2,9,12,14.	5,6,8,10.	5,6.
Rubus spp.	Blackberry	(4/)			
Rubus leucodermis	Western raspberry	(4/)	(4/)		(4/)
Rubus parviflorus	Western thimbleberry		12,14.		
Salix sp.	Willow	11.			
Salix scouleriana	Nuttall willow		1.		
Sambucus caerulea	Mountain blue elderberry		6.		1.
Solanum parishii	Parish nightshade		5.		
Styrax officinalis californica	California storax	1,6,7,8,9,10, 12.			2,3,4,7.
Symphoricarpos acutus	Spreading snowberry	4,5,13.	1,2,4,8,9,12, 14.		4.
Symphoricarpos rivularis	Snowberry				(4/)
Taxus brevifolia	Pacific Yew			(4/)	(4/)
Vitis californica	California wild grape				(3/)
Whipplea modesta	Whipplea	14.			

1/ More data on percent composition and abundance of plants are on file at the Department of Agronomy and Range Science, University of California, Davis.

2/ Varieties not differentiated.

3/ Mapped in quadrangle indicated but not recorded on plots.

4/ Observed in quadrangle indicated but not recorded on plots.

5/ Collected in quadrangle indicated but not recorded on plots.

Table 6--Five orders of soils in the French Gulch Quadrangle, by series, family, and subgroup

Series	Family	Subgroup
	Entisols	
Exchequer	Loamy, mixed, nonacid, thermic	Lithic Xerorthents
Corbett	Mixed, frigid	Typic Xeropsamments
	Inceptisols	
Kidd	Medial, mesic 1/	Lithic Vitrandepts
Modesty	Coarse-loamy, mixed, thermic	Typic Xerochrepts
Tish Tang Variant 2	Fine-loamy, mixed, mesic	Dystric Xerochrepts
Neuns	Loamy-skeletal, mixed, mesic	Dystric Xerochrepts
Chawanakee	Loamy, mixed, mesic, shallow	Dystric Xerochrepts
Chaix	Coarse-loamy, mixed, mesic	Dystric Xerochrepts
Kanaka	Coarse-loamy, mixed, thermic	Dystric Xerochrepts
Sheetiron	Loamy-skeletal, micaceous, mesic	Dystric Xerochrepts
Maymen	Loamy, mixed, mesic	Dystric Lithic Xerochrepts
Goulding	Loamy-skeletal, mixed, mesic	Lithic Xerochrepts
Millsholm	Loamy, mixed, thermic	Lithic Xerochrepts
Huse	Clayey, mixed, mesic	Lithic Xerochrepts
Auburn	Loamy, mixed, thermic	Ruptic-Lithic Xerochrepts
	Mollisols	
Los Gatos	Fine-loamy, mixed, mesic	Typic Argixerolls
Fiddletown Variant	Fine-loamy, mixed, mesic	Pachic Ultic Argixerolls
Henneke	Clayey-skeletal, serpentinitic, thermic	Lithic Argixerolls
San Andreas	Coarse-loamy, mixed, thermic	Typic Haploxerolls
Tollhouse	Loamy, mixed, mesic, shallow	Entic Haploxerolls
	Alfisols	
Redding	Fine, kaolinitic, thermic	Abruptic Durixeralfs
Greenfield	Coarse-loamy, mixed, thermic	Typic Haploxeralfs
Stonyford	Loamy, mixed, thermic	Lithic Mollic Haploxeralfs
Dubakella	Clayey-skeletal, serpentinitic, mesic	Mollic Haploxeralfs
Sobrante	Fine-loamy, mixed, thermic	Mollic Haploxeralfs
Behemotosh	Loamy-skeletal, mixed, mesic	Ultic Haploxeralfs
Marpa	Loamy-skeletal, mixed, mesic	Ultic Haploxeralfs
Boomer	Fine-loamy, mixed, mesic	Ultic Haploxeralfs
Holland	Fine-loamy, mixed, mesic	Ultic Haploxeralfs
Hotaw	Fine-loamy, mixed, mesic	Ultic Haploxeralfs
Musick	Fine-loamy, mixed, mesic	Ultic Haploxeralfs
Auberry	Fine-loamy, mixed, thermic	Ultic Haploxeralfs
Sierra	Fine-loamy, mixed, thermic	Ultic Haploxeralfs
Hoda	Fine, kaolinitic, mesic	Ultic Haploxeralfs
Newtown	Fine, montmorillonitic, thermic	Ultic Haploxeralfs
Newville	Fine, montmorillonitic, thermic	Mollic Palexeralfs
	Ultisols	
Horseshoe	Fine-loamy, mixed, mesic	Xeric Haplohumults
Sites	Clayey, kaolinitic mesic	Xeric Haplohumults
Diamond Springs	Fine-loamy, mixed, mesic 1/	Typic Haploxerults
Behemotosh Variant	Fine-loamy, mixed, mesic	Typic Haploxerults
Josephine	Fine-loamy, mixed, mesic	Typic Haploxerults

1/ Mapped as "thermic" in French Gulch Quadrangle.

REFERENCES

Abrams, Leroy.
1923-1960. Illustrated flora of the Pacific States. 4 vols. Stanford: Stanford University Press.

Albers, J. P.
1964. Geology of the French Gulch quadrangle, Shasta and Trinity Counties, California. U.S. Geol. Surv. Bull. 1141-J, 70 p.

Albers, John P.
1965. Economic geology of the French Gulch quadrangle, Shasta and Trinity Counties, California. California Div. Mines and Geol. Spec. Rep. 85, 43 p. illus.

Albers, J. P., A. R. Kinkel, Jr., A. A. Drake, and W. P. Irwin.
1964. Geology of the French Gulch quadrangle. U.S. Geol. Surv. Map GQ-336.

Bailey, Edgar H.
1966. Geology of northern California. California Div. Mines and Geol. Bull. 190, 508 p. illus.

Basile, Robert M.
1971. A geography of soils. Dubuque, Iowa: Wm. C. Brown Co. 152 p. illus.

California Department of Water Resources
1964. Shasta County investigations. Bull. 22, 239 p., illus.

California Resources Agency.
1970. Task force findings and recommendations on sediment problems in the Trinity River near Lewistown and a summary of the watershed investigation. 32 p., illus.

DeLapp, J., and R. Skolmen.
1961. Soil Vegetation Map SE ¼ Hoopa quadrangle, Humboldt County, California. Map plate 11D-4 and legend. California Region, U.S. Forest Serv.

Dunning, D.
1942. A site classification for the mixed-conifer selection forests of the Sierra Nevada. U.S. Forest Serv. Calif. Forest and Range Exp. Stn. Res. Note 28, 21 p., illus.

Franklin, Jerry F., and C. T. Dyrness.
1969. Vegetation of Oregon and Washington. USDA Forest Serv. Res. Pap. PNW-80, 216 p., illus. Pacific Northwest Forest and Range Exp. Stn., Portland, Oregon

Griffin, J. R., and C. O. Stone.
1967. MacNab cypress in northern California: a geographic review. Madroño 19(1):19-27.

Jepson, Willis Lynn.
1923-1925. A manual of the flowering plants of California. 1,238 p. illus. Berkeley: California Associated Students Store.

Kinkel, A. R., Jr., W. E. Hall, and J. P. Albers.
1956. Geology and base metal deposits of west Shasta copper-zinc district, Shasta County, California. U.S. Geol. Surv. Prof. Pap. 285, 156 p., illus.

Kraebel, Charles J.
1955. Conquering Kennett's Gullies. Amer. For. 61(12): 36-39, 42, 45, illus.

McDonald, Philip M.
1969. Silvical characteristics of California black oak *(Quercus kelloggii Newb.)*. USDA Forest Serv. Res. Pap. PSW-53, Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. 20 p., illus.

McMinn, Howard E.
1939. An illustrated manual of California shrubs. 689 p., illus. San Francisco: J. W. Stacey, Inc.

McMinn, Howard. E.
1942. Ceanothus II, A systematic study of the genus *Ceanothus.* p. 131-303. Santa Barbara Botanic Garden, Santa Barbara.

Munz, Philip A.
1968. Supplement to a California flora. 224 p. Berkeley: University of California Press.

Munz, Philip A., and David D. Keck.
1959. A California flora. 1,681 p., illus. Berkeley: University of California Press.

Murphy, M. A., G. L. Peterson, and P. V. Rodda.
1964. Revision of Cretaceous lithostratigraphic nomenclature, Northwest Sacramento Valley, California. Bull. Amer. Assoc. Pet. Geol. 48(4):496-502.

Powell, W. R.
1965. Soil fertility studies: No. 15 Redding Series. Calif. Div. Forestry, Sacramento, Calif. 2 p.

Sampson, Arthur W., and Beryl S. Jespersen.
1963. California range brushlands and browse plants. Calif. Agric. Exp. Stn. Ext. Serv. Manual 33, 162 p.

Soil Survey Staff.
1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 p. illus.

Soil Survey Staff.
1960. Soil classification, a comprehensive system, 7th approximation. Soil Conservation Serv. Washington, D.C. 265 p., illus.

Soil Survey Staff.
1970. Selected Chapters from the unedited text of the Soil Taxonomy of the National Cooperative Soil Survey. Soil Conservation Serv. 486 p. Washington, D.C.

Soil Survey Staff.
1972. Soil Series of the United States, Puerto Rico and the Virgin Islands: Their Taxonomic Classification. 374 p. Washington, D.C.; Soil Conservation Serv.

Thorp, James, and Guy D. Smith.
1959. Higher categories of soil classification: order, suborder, and great soil groups. Soil Sci. 67:116-126, illus.

U.S. Geological Survey.
1944. French Gulch quadrangle, California, 15-minute series (topographic). Denver, Colo.

U.S. Forest Service, California Forest and Range Experiment Station.
1939. Vegetation types of California Redding Quadrangle. Berkeley, Calif. Sheet 23.

U.S. Forest Service, California Forest and Range Experiment Station.
1949. The timber stand and vegetation-soil maps of California. Berkeley, Calif. 15 p., illus.

U.S. Forest Service, California Forest and Range Experiment Station.
1954. Field manual, soil-vegetation surveys in California. Berkeley, Calif. 95 p., illus.

U.S. Weather Bureau.
1965. Climate of Shasta County. Univ. Calif. Agric. Ext.

Serv., Redding, California. 42 p., illus.

Waring, R. H.
1969. Forest plants of the eastern Siskyous: their environmental and vegetational distribution. Northwest Sci. 43(1):1-17.

Wieslander, A. E.
1935. A vegetation type map of California. Madroño 3(3):140-144.

Zinke, Paul J., and W. L. Colwell, Jr.
1965. Some general relationships among California forest soils. Forest Soil Relationships in North America. p. 354-365, illus. Corvallis, Oregon: Oregon State University Press.

☆ GPO 792

SOIL-VEGETATION SURVEY

COOPERATING AGENCIES
PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION — FOREST SERVICE — U.S. DEPT. OF AGRICULTURE
DIVISION OF AGRICULTURAL SCIENCES — UNIVERSITY OF CALIFORNIA —
DIVISION OF FORESTRY — DEPARTMENT OF CONSERVATION — THE RESOURCES AGENCY — STATE OF CALIFORNIA

SOIL-VEGETATION MAP

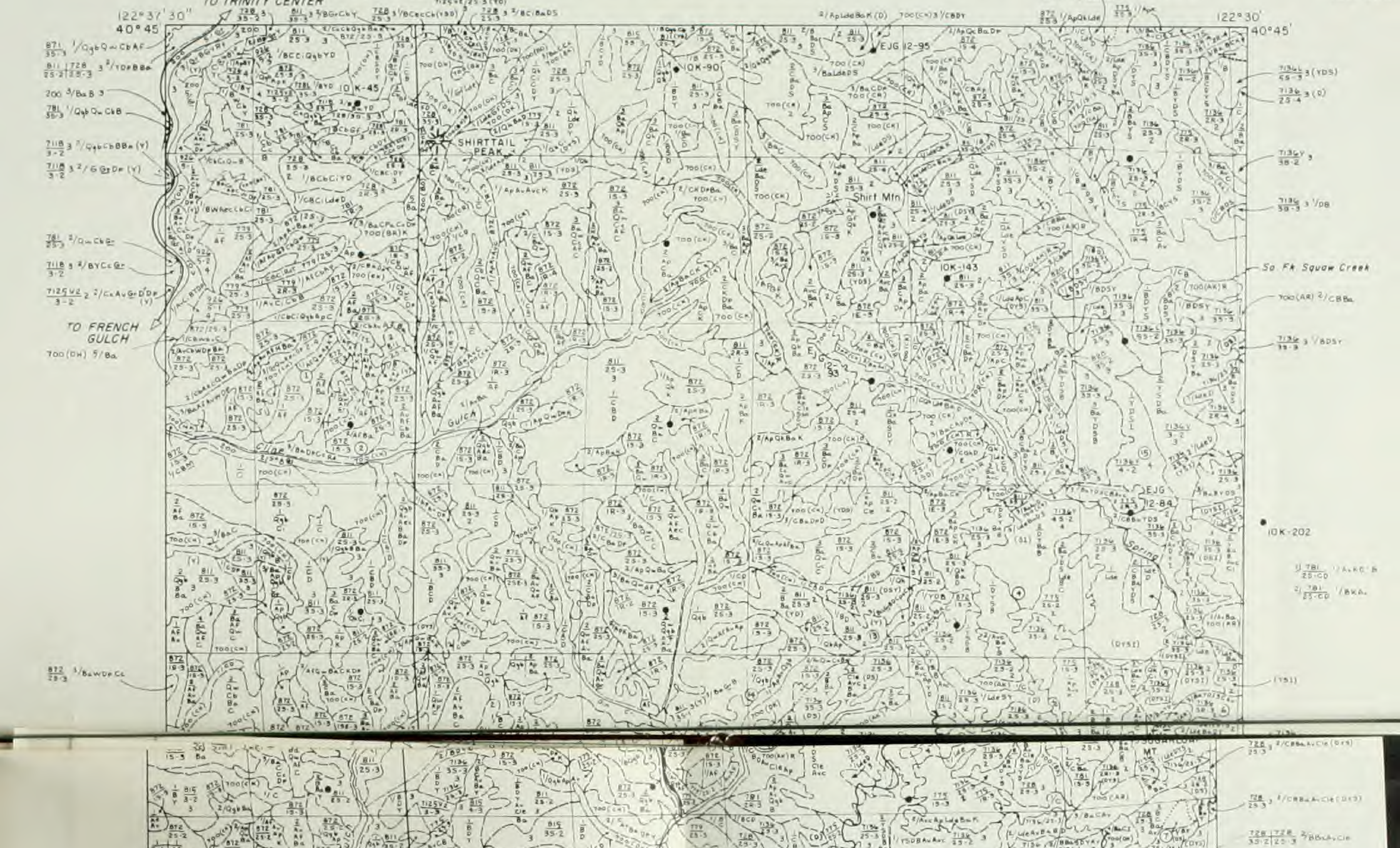
by

Ben F. Smith, Earl B. Alexander and James I. Mallory

SOIL SERIES AND PHASES
COVER PERCENT CLASSES OF WOODY VEGETATION
SPECIES COMPOSITION OF DOMINANT VEGETATION
SITE QUALITY OF TIMBER CROPLANDS
SOIL-VEGETATION PLOT LOCATIONS ● EJG 12-81

24D-1

FRENCH GULCH QUADRANGLE
(Northeast Quarter)
SHASTA COUNTY
CALIFORNIA



Accompanies report SOILS and VEGETATION of the FRENCH GULCH QUADRANGLE —(24D-1,2,3,4) Shasta and Trinity Counties, California.

Classification and mapping, 1962 to 1964 & 1969.
Map compilation by J. Klingensmith, 1963.
Edition of December 1973.

Scale 1:31680

$\frac{1}{2}$ 0 1 2

Major Roads
● Aerial Photo Center

Base map: N.E. $\frac{1}{4}$ U.S.G.S. French Gulch Quadrangle, 15' series. Edition of 1957. Mt. Diablo Meridian.
Land grid compiled from U.S.F.S., N.P.S., and C.D.F. source maps. No final accuracy claimed.
Aerial photography: BUY 1952, EJG 1961, SC 1962.
Soil names subject to final correlation.

(DSI)

ıes subject to
orrelation.

SOIL-VEGETATION SURVEY
COOPERATING AGENCIES
PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION —
FOREST SERVICE — U.S. DEPT. OF AGRICULTURE
DIVISION OF AGRICULTURAL SCIENCES — UNIVERSITY OF CALIFORNIA —
DIVISION OF FORESTRY — DEPARTMENT OF CONSERVATION
THE RESOURCES AGENCY — STATE OF CALIFORNIA

SOIL-VEGETATION MAP

by

Chester O. Stone, James M. Crawford and James I. Mallory

SOIL SERIES AND PHASES
COVER PERCENT CLASSES OF WOODY VEGETATION
SPECIES COMPOSITION OF DOMINANT VEGETATION
SITE QUALITY OF TIMBER CROPLANDS
SOIL-VEGETATION PLOT LOCATIONS

24D-2

FRENCH GULCH
QUADRANGLE
(Northwest Quarter)
SHASTA COUNTY
and
TRINITY COUNTY
CALIFORNIA

Accompanies report: SOILS and VEGETATION of the FRENCH GULCH QUADRANGLE — (24D-1,2,3,4) Shasta and Trinity Counties, California.
Classification and mapping, 1962 to 1964 & 1968.
Map compilation by J. Klingensmith, 1963.
Edition of December 1973

Scale 1:31680

0 — 1 — 2 Miles

Base map: N.W. 1/4 U.S.G.S. French Gulch Quadrangle, 15' series. Edition of 1957. Mt. Diablo Meridian.
Land grid compiled from U.S.F.S., N.P.S. and C.D.F. source maps. No final accuracy claimed.
Aerial photography: BUY 1952, EJG 1961, SC 1962.

Soilnames subject to final correlation.

24D-3

SOIL-VEGETATION SURVEY
COOPERATING AGENCIES
PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION——
FOREST SERVICE——U.S. DEPT. OF AGRICULTURE
DIVISION OF AGRICULTURAL SCIENCES——UNIVERSITY OF CALIFORNIA——
DIVISION OF FORESTRY——DEPARTMENT OF CONSERVATION——
THE RESOURCES AGENCY——STATE OF CALIFORNIA

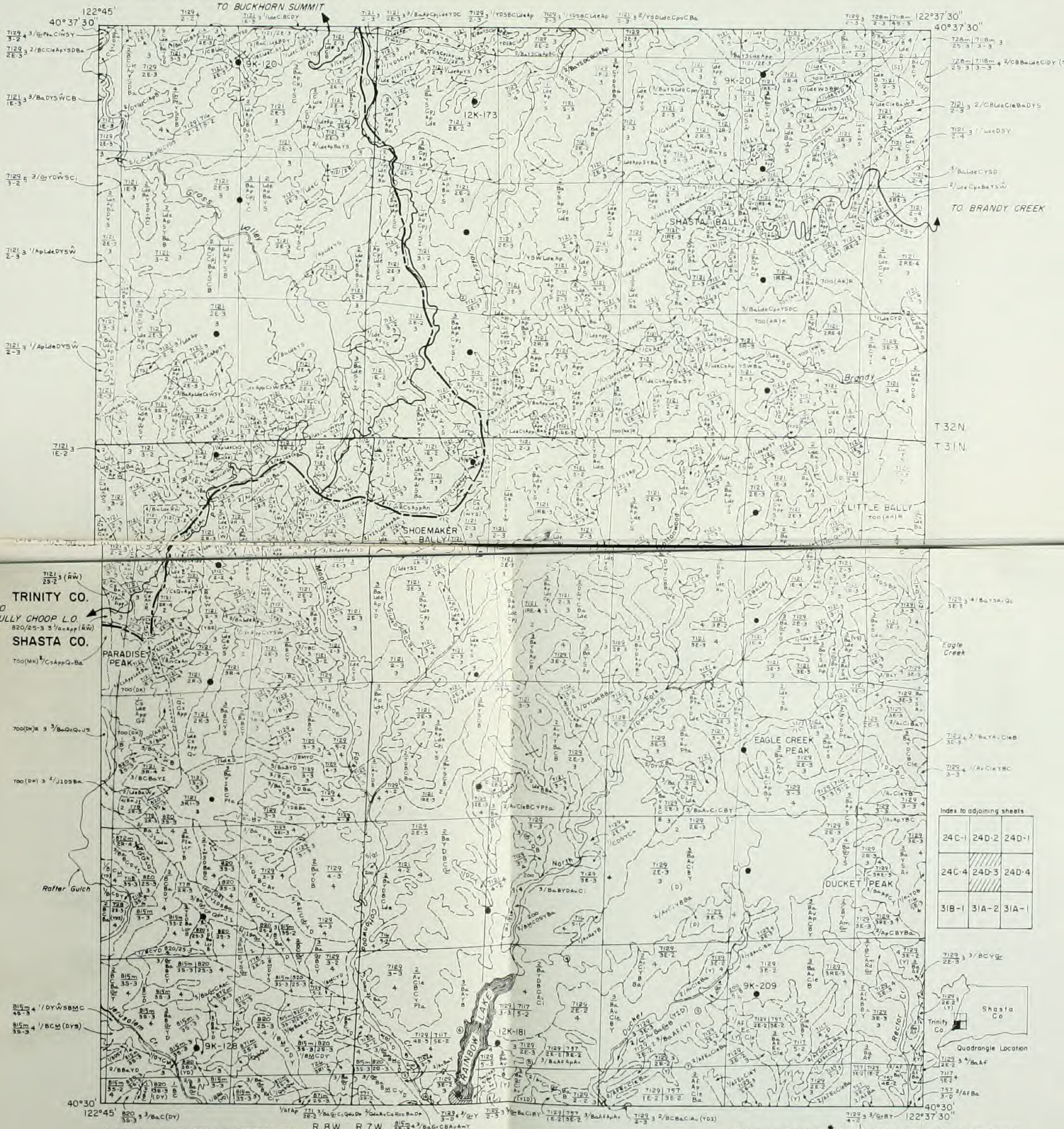
SOIL-VEGETATION MAP

By

James M. Crawford, Chester O. Stone and James I. Mallory

SOIL SERIES AND PHASES
COVER PERCENT CLASSES OF WOODY VEGETATION
SPECIES COMPOSITION OF DOMINANT VEGETATION
SITE QUALITY OF TIMBER CROPLANDS
SOIL-VEGETATION PLOT LOCATIONS

FRENCH GULCH QUADRANGLE
(Southwest Quarter)
SHASTA COUNTY
and
TRINITY COUNTY
CALIFORNIA



Accompanies report: SOILS and VEGETATION of the FRENCH GULCH QUADRANGLE—(24D-1, 2, 3, 4), Shasta and Trinity Counties, California.
Classification and mapping, 1961 to 1964 & 1968. Map compilation by D. Johnson, 1962; J. Klingensmith, 1966. Edition of December 1973.

Scale 1:31680

1/2 0 1 2 Miles

Major Roads

Aerial Photo Center

Base map and land grid: S.W. 1/4 U.S.G.S. French Gulch Quadrangle, 15' series. Edition of 1957. Mt. Diablo Meridian.
Aerial photography: BUY 1952.
*Land grid compiled from U.S.F.S., N.P.S., and C.D.F. source maps. No final accuracy claimed.
Soil names subject to final correlation.

FRENCH GULC[H]
QUADRANGLE
(Southeast Quart[er])
SHASTA COUNT[Y]
CALIFORNIA

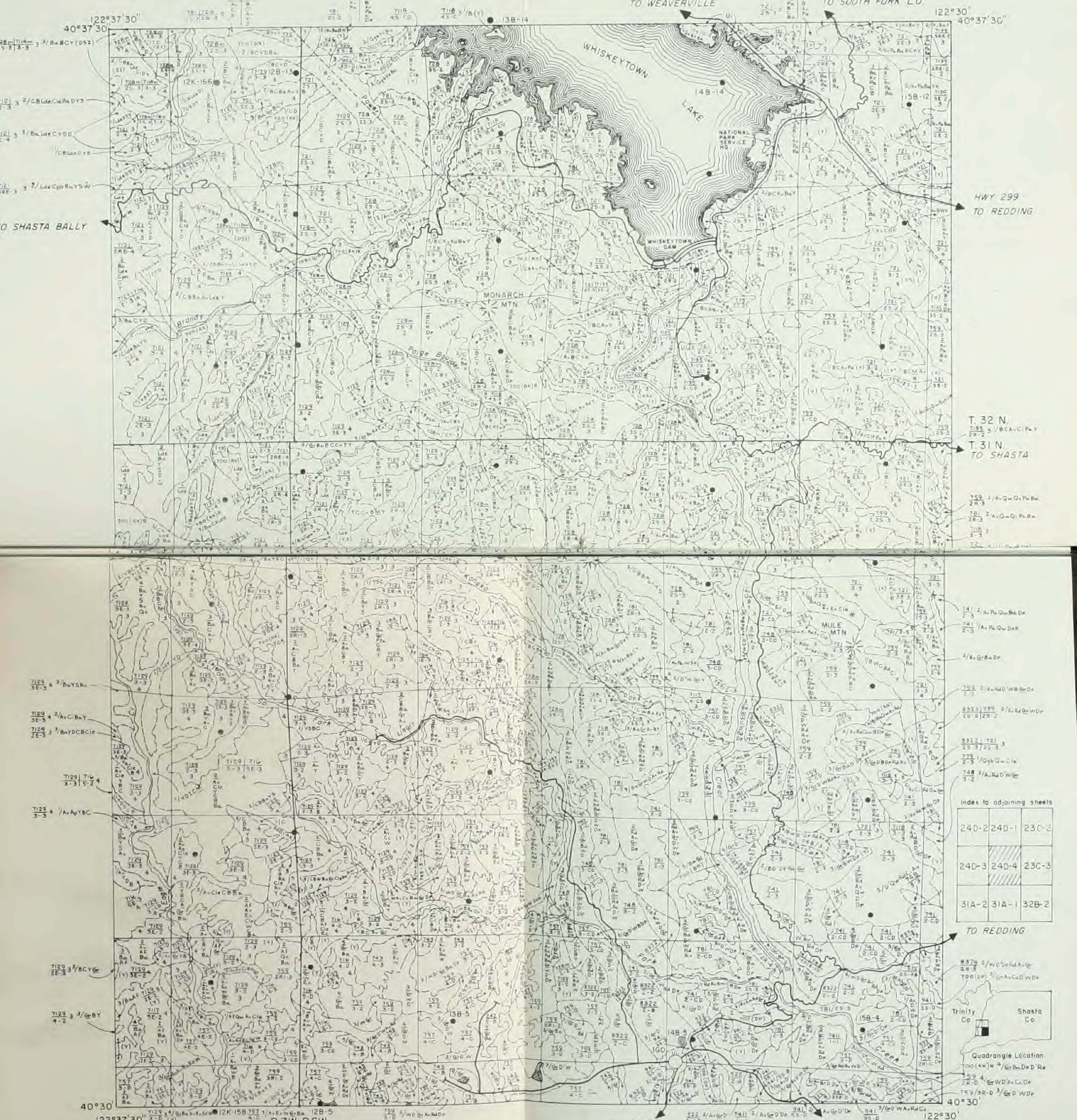
SOIL-VEGETATION SURVEY
COOPERATING AGENCIES:
PACIFIC SOUTHWEST FOREST & RANGE EXPERIMENT STATION — FOREST SERVICE — U.S. DEPT. OF AGRICULTURE
DIVISION OF AGRICULTURAL SCIENCES — UNIVERSITY OF CALIFORNIA
DIVISION OF FORESTRY — DEPT. OF CONSERVATION — THE RESOURCES AGENCY — STATE OF CALIFORNIA

SOIL-VEGETATION MAP

by

James I. Mallory and Theodore A. Klaseen

SOIL SERIES AND PHASES
COVER PERCENT CLASSES OF WOODY VEGETATION
SPECIES COMPOSITION OF DOMINANT VEGETATION
SITE QUALITY OF TIMBER CROPLANDS
SOIL-VEGETATION PLOT LOCATIONS



Accompanies report: SOILS and VEGETATION of the FRENCH GULCH QUADRANGLE — (24D-1, 2, 3, 4)
Shasta and Trinity Counties, California
Classification and mapping, 1962 to 1964 & 1968
Map compilation by J. Klingensmith, 1963
Edition of December 1973

Scale: 1:31680

½ 0 1 2 Miles

Major Roads
Aerial Photo Center

Base map: N.E. ¼ U.S.G.S. French Gulch Quadrangle, 15' series. Edition of 1957. Mt. Diablo Meridian.
Land grid compiled from U.S.F.S., N.P.S. and C.D.F. source maps. No final accuracy claimed.
Aerial photography: BUY 1952, EJG 1961, SC 1962.

Soil names subject to final correlation

CONTENTS

THE AUTHOR

WILMER L. COLWELL, JR. is in charge of the Cooperative Soil-Vegetation Survey, headquartered at Berkeley, California. A 1938 forestry graduate of North Carolina State University, he also holds a master's degree (1950) from the University of California, Berkeley. He joined the Station staff in 1946.

ACKNOWLEDGMENTS

I thank the Soil-Vegetation Survey staff for their contributions to this publication: *James I. Mallory,* range conservationist, and *Benjamin F. Smith,* soil scientist, Pacific Southwest Forest and Range Experiment Station; and *Chester O. Stone,* forester, California Division of Forestry, for their contributions and critical review; and *W. Robert Powell,* associate specialist, in the Department of Agronomy and Range Science, University of California, Davis for his assistance in preparation of the explanations of the tables.

Basic information about soils and vegetation—their characteristics, location, extent, and relationships—is especially useful to the resource manager. It provides him with a foundation for understanding and managing the ecosystem—the ecological community that includes soils, vegetation, animals, climate, and man. By applying an ecological approach, he can make more efficient and productive use of the land and its resources. He can apply management procedures that have proved successful in areas of known soils and vegetation to other areas with the same characteristics.

Soil-vegetation surveys are designed to produce useful maps and information. The data are useful to the practitioner as well as to the researcher. In land management research, prior knowledge of the ecosystem is mandatory if the work is to succeed. If the vegetation is to be changed, the information from such surveys might be used to estimate probable results.

This publication contains information about the soil and vegetation symbols and other features shown on the 7½-minute soil-vegetation quadrangle maps. It also explains and defines the terminology used in the six tables that accompany each map.

The soil-vegetation maps were prepared by the California State Cooperative Soil-Vegetation Survey Project, Pacific Southwest Forest and Range Experiment Station, Forest Service. The Project is financed through appropriations of the California Legislature to the Division of Forestry, Department of Conservation, Resources Agency of California. Cooperating organizations in the Soil-Vegetation Survey are the Division of Forestry; the Department of Agronomy and Range Science, Department of Soils and Plant Nutrition, University of California, Davis; Department of Forestry and Conservation, University of California, Berkeley; and the Pacific Southwest Forest and Range Experiment Station at Berkeley. Project leader is Wilmer L. Colwell, Jr., Pacific Southwest Forest and Range Experiment Station at Berkeley.

The Soil-Vegetation maps are for sale only. The price of each 7½-minute quadrangle map is 45 cents. Tables accompany each map.

Order should state specifically which quadrangles are desired. Make checks or money orders for the exact amount (minimum orders are $1.00) payable to the Treasurer of the United States, and send to:

Regional Forester
U.S. Forest Service
630 Sansome Street
San Francisco, California 94111

For a list of available maps, write to the above address.

LEGEND TO THE MAPS

Base Maps

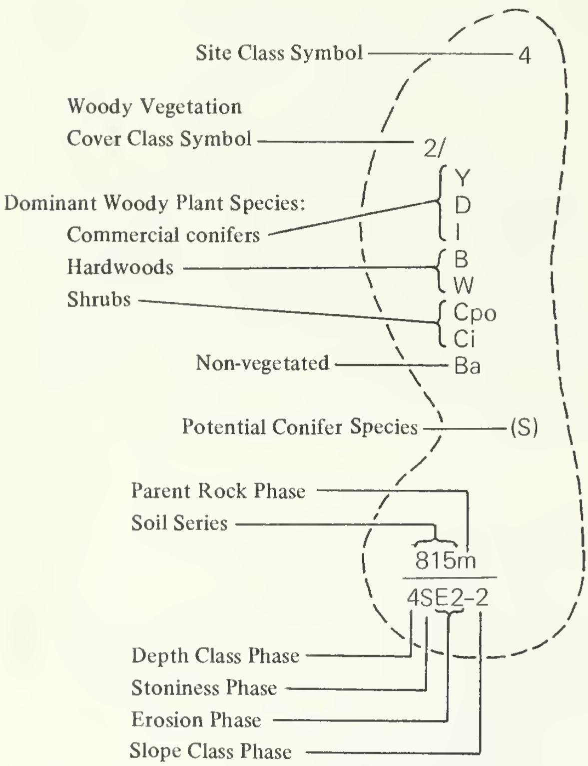
Base maps used for the Soil-Vegetation maps are specially prepared by the Pacific Southwest Forest and Range Experiment Station, mostly from published sources. Each Soil-Vegetation map consists of a standard 7½-minute quadrangle unit at the scale of 2 inches = 1 mile.

Every effort has been made to fit the soil and vegetation boundaries to the topography of the base map. Land subdivisions have been positioned as accurately as source information and map control points permit. If a precise fit of the data to land subdivisions for small areas is required, ground checks against known corner locations, fence boundaries, or other features should be carried out, preferably by using aerial photographs.

Contour lines, minor roads, small drainages, and other map details are not shown on the maps so as not to obliterate other data. If such map detail is required, refer to U.S. Geological Survey topographic maps, which are used as sources for the base information. The base maps are listed in the lower right corner of each quadrangle map.

Symbols Shown on the Maps

All soil and vegetation information for each mapping area is shown by coded symbols on the map as in the example below. Following this example are detailed explanations of the symbols.



Soil Symbols

Soils are mapped by soil series and phases (depth class, slope class, and certain other soil phases). The Soil Survey Manual (Soil Survey Staff 1951) has been used as a general standard of reference for terminology and concepts. Soil information is coded in the form of a numerical fraction, e.g.:

$$\frac{815m}{4SE\text{-}1} = \frac{\text{Soil Series/soil series modifier}}{\text{depth class/other phases/-slope class}}$$

Soil series can be coded in three categories defined as follows:

Soil series names are designated by numbers of three or four digits in the numerator of the fraction.

Soil series variants are soils of limited extent which are distinctly different, but similar and closely related to a known soil series. They are designated by the symbol "V" following the soil series symbol, e.g. 815V.

Soils of limited extent which are distinctly different from and unrelated to a known soil series are indicated by an "X," "Y," or "Z" instead of the final numeral in the soil series symbol, e.g. 84X.

Soil series modifiers give additional information about the soil series or indicate a variation from the normal characteristic of the series. They have special symbols and examples as defined below:

Parent rock or parent material phases are designated by a lower case letter following the soil series number, e.g. 815m.

Variations from normal are shown by upper case letters (different from any given above) following the soil series number, e.g. a landslide phase, 815L, or a taxadjunct, 815A, etc.

If there is more than one variant or taxadjunct of a given soil series designated by the same letter, each is numbered in succession, e.g.:

Soil series variants:	815V1, 815V2
Taxadjuncts:	815A1, 815A2

Other soil phases are designated by letters and numbers in the denominator of the fraction. Soil *depth class* is designated by the first digit. *Rockiness, stoniness, and/or erosion* are designated by letters and numbers immediately following the depth class symbol *(table 2)*. The *slope class* in the delineated area is represented by a letter or number symbol which is separated by a hyphen from the other phase symbols *(table 1)*.

In some areas an association of two soils occurs in such an intricate pattern that they cannot be indicated separately at the scale of mapping. Such a *soil complex* is designated by two fractional symbols separated by a vertical line, e.g.,

$$\frac{847 \mid 752}{2\text{-}2 \mid 3\text{-}2} \quad \text{or} \quad \frac{847 \mid 752}{3\text{-}2}$$

The dominant soil unit (51 to 80 percent of a delineated area) appears on the left.

Unclassified soil areas are usually agricultural or potentially agricultural lands for which, in many cases, soil surveys have already been made by other agencies, such as the U.S. Soil Conservation Service. Symbols for unclassified soils are "100," "200," or "400," but are not in fraction form; sometimes a letter follows the number indicating further breakdown of the general definition of the symbols, e.g., 200W *(table 1)*.

Miscellaneous land types have little or no soil, or soil that cannot feasibly be classified. They are distinguished as a group by the symbol "700," also not in fraction form. Subdivisions within the groups are shown by letter symbols in parentheses following the "700" symbol, e.g. 700(CK) *(table 1)*.

Vegetation Symbols

Plant species are represented by letter symbols, such as Af for chamise *(Adenostoma fasciculatum)* and D for Douglas-fir *(Pseudotsuga menziesii) (table 3)*. Dominant species in a delineated area (excluding individual grass species and most associated herbs) are indicated by one or more symbols which may be grouped. Each group of symbols represents an element which may be either a broad kind of vegetation (commercial conifers, minor conifers, hardwoods, shrubs, bushy herbs, grass, marsh) or some other landscape unit (nonvegetated and rock, cultivated, urban-industrial). Each delineated area may have one or more elements occupying from 5 to 100 percent of the ground area. Elements can be determined on the map by grouping the appropriate symbols. For example, an area has the symbols Y D I B W Cpo Ci Ba. They represent four elements, respectively: commercial conifers (YDI), hardwoods (BW), shrubs (CpoCi), and non-vegetated (Ba).

Elements are listed in order of abundance with the one listed first making up the greatest proportion of the cover. Likewise, the order of symbols within an element indicates the relative abundance of the species within that element. Symbols of vegetation elements not classified as to species (grass, marsh, and bushy herbs) and the non-vegetation element (barren) are included among plant symbols in proper order of abundance of elements or may stand alone as the case may be.

In the above example, there is a greater proportion of commercial conifers than hardwoods, shrubs, or grass, and there is more Y than D, more D than I. But the proportion of I is not necessarily greater than B or Ba. If five or more species symbols appear in one group, the relative abundance of the species is variable within the delineated area. For further information on the classification system, see the folio titled "Timber Stand and Vegetation-Soil Maps of California," Jan. 15, 1949 (U.S. Forest Serv. California Forest and Range Exp. Stn. 1949), and the "Field Manual, Soil-Vegetation Surveys in California" (U.S. Forest Serv., California Forest and Range Exp. Stn. 1954).

A species must occupy 20 percent or more of the crown space of the element to which it belongs to be mapped in a delineated area. The individual element also must comprise the following minimum parts of a delineated area: crowns of commercial conifers—5 percent or more of the ground space; hardwoods and minor conifers—each at least 5 percent, or 20 percent when in combination with 20 percent or more of commercial conifers; shrubs—at least 5 percent, or 20 percent when in combination with 20 percent or more of a tree element; and all other elements—at least 20 percent if they appear on the map.

In some areas, logging, burning, or clearing may have eliminated one or more (or all) species of commercial conifer trees. In such areas, symbols of conifers eliminated or reduced to less than 5 percent cover are shown in parentheses.

The approximate percent of the ground covered by woody vegetation (i.e., canopy of all trees and shrubs combined) is shown as a *cover* class symbol which appears as a number above or to the left of the vegetation species symbols and separated from them by a line, e.g., 2/YDIBWCpoCiBa. The cover class symbols and explanation are:

	Cover class	*Ground covered (percent)*
Cover symbol:		
1	Dense	> 80
2	Semidense	50 - 80
3	Open	20 - 50
4	Very open	5 - 20
5	Extremely open	< 5

In areas without climate and soil suitable for growing commercial conifer crops, the symbol "N" precedes the cover class symbol in numerator portion of the fraction. "N" is not used in cultivated and urban-industrial areas. This symbol is not used on Soil-Vegetation maps in Shasta and Trinity Counties.

In some areas, distinct vegetation units cannot be shown separately at the scale of mapping. In such cases, two groups of cover class and species symbols are shown with a vertical line separating them, e.g.,

1	2
D	T
R	M
T	Ba

Type-Acre Sampling Plots

Type-acre soil-vegetation sampling plots are established in a mapped area. These plots are not uniformly distributed because their locations are chosen to be representative of the more extensive (or sometimes unusual) combinations of soil and vegetation. A detailed soil profile description and intensive vegetation inventory are made at these sites. Plot locations *(tables 4, 5)* are shown on the map by circled numbers, e.g., ③.

Timber Site Symbols

Site quality (capacity of the land for growing commercial conifer timber) is indicated on the maps by single number symbols (Arabic or Roman) such as 4 and II. For each delineated commercial timber cropland area a predominant site quality class is designated, based on the age-height relationships of trees. The site classification system used depends on the species type and location of the survey area.

The *pine, fir, pine-Douglas-fir,* and *pine–Douglas-fir–fir types* are graded by two different site class curves: (1) in terms of the total height that average dominant trees reach at 300 years of total age by 25-foot class intervals (Dunning 1942), or (2) in terms of the average total height of dominant trees at a base age of 100 years measured at breast height by 20-foot class intervals (Arvanitis, et al. 1964).

Site class symbols are designated by numbers 1 through 7:

Class symbol:	*Dunning height (feet)* At 100 years	*Dunning height (feet)* At 300 years	*Arvanitis height (feet)* at 100 years
1	52	75	60
2	67	100	80
3	82	125	100
4	102	150	120
5	122	175	140
6	140	200	160
7	160 (est)	225	180

Dunning's site classes are used in the types surveyed in Del Norte, Shasta, Sonoma, and Trinity Counties. Arvanitis site classes apply to the types mapped in Butte, Calaveras, Plumas, Siskiyou, Tuolumne, and Yuba Counties.

Douglas-fir and *redwood types* are graded in terms of the total height that average dominant and codominant Douglas-fir trees reach at 100 years of age by 30-foot classes (McArdle 1949 rev. 1961). Site class symbols are designated by Roman numbers I through V.

Class symbol:	Height at 100 years *(feet)*
I	200
II	170
III	140
IV	110
V	80

The site curves used have been adjusted to the average height of dominant Douglas-fir trees (Staebler 1948).

Spruce and *lodgepole pine-mountain hemlock* types are each considered a single site quality class:

Symbol	
X	Spruce
XX	Lodgepole pine-mountain hemlock

In areas without climate and soil suitable for growing commercial conifer crops, the site index symbol is omitted.

Soil and Vegetation Boundaries

Soil or vegetation boundaries or both are normally shown on the map by dashed lines. In some places, however, it is necessary to show a soil boundary distinct from a vegetation boundary. Where this is done, a dotted line indicates a soil boundary. When needed, a double-headed arrow is used to show the appropriate adjacent soil.

Other Features on Maps

Photo centers: The locations of the centers of aerial photographs from which the map data are compiled are shown on the map by large dots. This will facilitate use of the map with aerial photos.

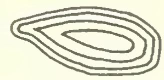
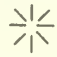
Roads: Some are shown for orientation purposes.

Drainage ways.—Some major drainages are shown for orientation purposes.

Special features: Features too small to delineate are shown by these symbols:


Spring


Wet spot

	Small marsh or wet meadow		Rock escarpment
	Severely eroded spot		Pond or reservoir
	Prominent rock outcrop		Named peak

TABLES TO ACCOMPANY MAPS

Table 1 lists the soil series mapped in the quadrangle and gives some general characteristics of each. The soil series names used here are based on present concepts of the series and are subject to review and correlation. The numbers under the soil name indicate the month and year of the soil series description used as a reference. Date omitted indicates the soil characteristics are not keyed to a specific description but to the soil as described in the area. Local variations must be expected in characteristics listed because terms (except slope class) apply to the soil series in general. Symbols in parentheses indicate the range of slope classes for all phases of the soil series in the quadrangle only. Detailed descriptions of individual soil series are on file at the University of California, Department of Soils and Plant Nutrition at Berkeley and Davis, and Pacific Southwest Forest and Range Experiment Station at Berkeley, California.

Table 2 is a legend of symbols for soil series, phases (excluding slope), and other units mapped. It gives selected behavior characteristics including permeability, general drainage, erosion hazard, hydrologic group, and estimated suitability for commercial timber production and for extensive range use.

Table 3 defines the symbols for plant species and other landscape units occurring in one or more types on the map and symbols of species listed as browse on type-acre sampling plots *(table 4)*. Given for each species are scientific name, common name, growth habit, sprouting nature, and browse value. Scientific plant names *(tables 3, 5)* mostly follow Munz and Keck (1959) and Munz (1968). The use of trinomials for "typical" varieties (and subspecies) of species having two or more varieties is in accordance with the International Code of Botanical Nomenclature (1972). The use of a binomial when varieties exist indicates that varieties were not differentiated. Common names mostly follow Jepson (1923), McMinn (1939), and local usage. Browse values are based on and extrapolated from Sampson and Jesperson (1963).

Table 4 presents a portion of the data taken from type-acre sampling plots that is principally concerned with livestock and wildlife use. It includes date of sampling, plot location, aspect and percent slope, soil series and phases, woody cover class (overstory), information on soft chess growing on the plot, percent of ground covered by various vegetation and landscape units as measured below a reference plane 4½ feet above the ground, and a list of woody species with available browse.

The soil series, soil phase, and woody cover class symbols may not correspond to those in the delineated areas of the map in which the plots are located because of scale of mapping. Detailed descriptions of soil profiles at these plot locations are on file at the Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Soft chess *(Bromus mollis)* is one of the most common annual range grasses in California. Height and stage of maturity of this grass together with date of sampling and other data give an indication of site and kind of season or year for the plot area.

Table 5 lists all plant species recorded for the quadrangle. Although not an exhaustive floristic list for the area, it is quite complete for woody plants in dry upland habitats. Given for each species are scientific name, common name, whether the species was mapped, type-acre sampling plots on which it was found, or whether it was simply observed to occur somewhere in the quadrangle. Scientific names mostly follow Munz and Keck (1959) and Munz (1968). Common names mostly follow Abrams (1923-1960), Jepson (1923), Munz and Keck (1959), Munz (1968), and local usage. Because percent ground cover (see table 4) and species composition of herbaceous component of vegetation often vary from year to year, these data are preliminary and describe plots at date of sampling. More data on percent composition and abundance of species are on file at Department of Agronomy and Range Science, University of California, Davis and at Pacific Southwest Forest and Range Experiment Station, Berkeley, California.

Table 6 lists the current taxonomic classification of the soils found in the quadrangle, according to National Cooperative Soil Survey standards.

The soil classification system currently used was adopted for general use in the United States in 1965 (Basile 1971; Soil Survey Staff 1960). It has six categories. The broadest category is the order, followed by suborder, great group, subgroup, family, and the series. The criteria used as a basis for classification are soil properties that are observable and measurable. The placement of the smallest unit—the soil series—in the current system may change as more precise information becomes available.

The 10 soil orders recognized are defined as follows:

Entisols: young mineral soils that do not have genetic horizons or barely have the beginning of such horizons.

Inceptisols: mineral soils in which horizons have started to develop, and are young but not on recent land surfaces.

Mollisols: very dark colored and base-rich soils with a thick, friable, dark-colored surface layer.

Alfisols: soils that have clay-enriched B horizons with medium or high base saturation and usually have light-colored surface horizons.

Ultisols: well developed soils that have clay-enriched B horizons with low base supply or low base saturation decreasing with depth.

Vertisols: clayey soils that shrink and have wide deep cracks during dry periods and that swell closing the cracks, in moist seasons.

Aridisols: primarily soils in dry areas, pale in color and generally soft when dry or have distinct structure.

Spodosols: usually gray to light gray podzol or podzolic soils, generally infertile, and developed from siliceous parent materials in cool humid climates.

Oxisols: reddish, yellowish, or grayish soils of tropical and subtropical regions, are deeply weathered, and formed on gentle slopes on old surfaces.

Histosols: soils that are dominantly organic from bogs, peats, and mucks.

REFERENCES

Abrams, Leroy.
1923-1960. Illustrated flora of the Pacific States. 4 vols. Stanford: Stanford University Press.

Arvanitis, L. G., J. Lindquist, and M. Palley.
1964. Site index curves for even-aged young-growth ponderosa pine of the west-side Sierra Nevada. California Forestry and Forest Products 35, 8 p.

Basile, Robert M.
1971. A geography of soils. Dubuque, Iowa: Wm. C. Brown Co. 152 p., illus.

Eleventh International Botanical Congress.
1972. International code of botanical nomenclature. Adopted August 1969. Utrecht, Netherlands, 2 p.

Jepson, Willis Lynn.
1923-1925. A manual of the flowering plants of California. 1,238 p. illus. Berkeley: California Associated Students Store.

McArdle, Richard E., W. H. Meyer, and D. Bruce.
1930. The yield of Douglas fir in the Pacific Northwest. Rev. 1949 and 1961. U.S. Dep. Agric. Tech. Bul. 201, 64 p.

McMinn, Howard E.
1939. An illustrated manual of California shrubs. 698 p., illus. San Francisco: J. W. Stacey, Inc.

Munz, Philip A.
1968. Supplement to a California flora. 224 p. Berkeley: University of California Press.

Munz, Philip A., and David D. Keck.
1959. A California flora. 1,681 p., illus. Berkeley: University of California Press.

Sampson, Arthur W., and Beryl S. Jesperson.
1963. California range brushlands and browse plants. Calif. Agric. Exp. Stn. Ext. Serv. Manual 33, 162 p.

Soil Survey Staff.
1951. Soil survey manual. U.S. Dep. Agric. Handb. 18, 503 p. illus.

Soil Survey Staff.
1960. Soil classification, a comprehensive system, 7th approximation. Soil Conservation Serv. Washington, D.C. 265 p., illus.

Staebler, George R.
1948. Use of dominant tree heights in determining site index for Douglas-fir. U.S. Forest Serv. Pacific Northwest Forest and Range Exp. Stn. For. Res. Note 44, 3 p.

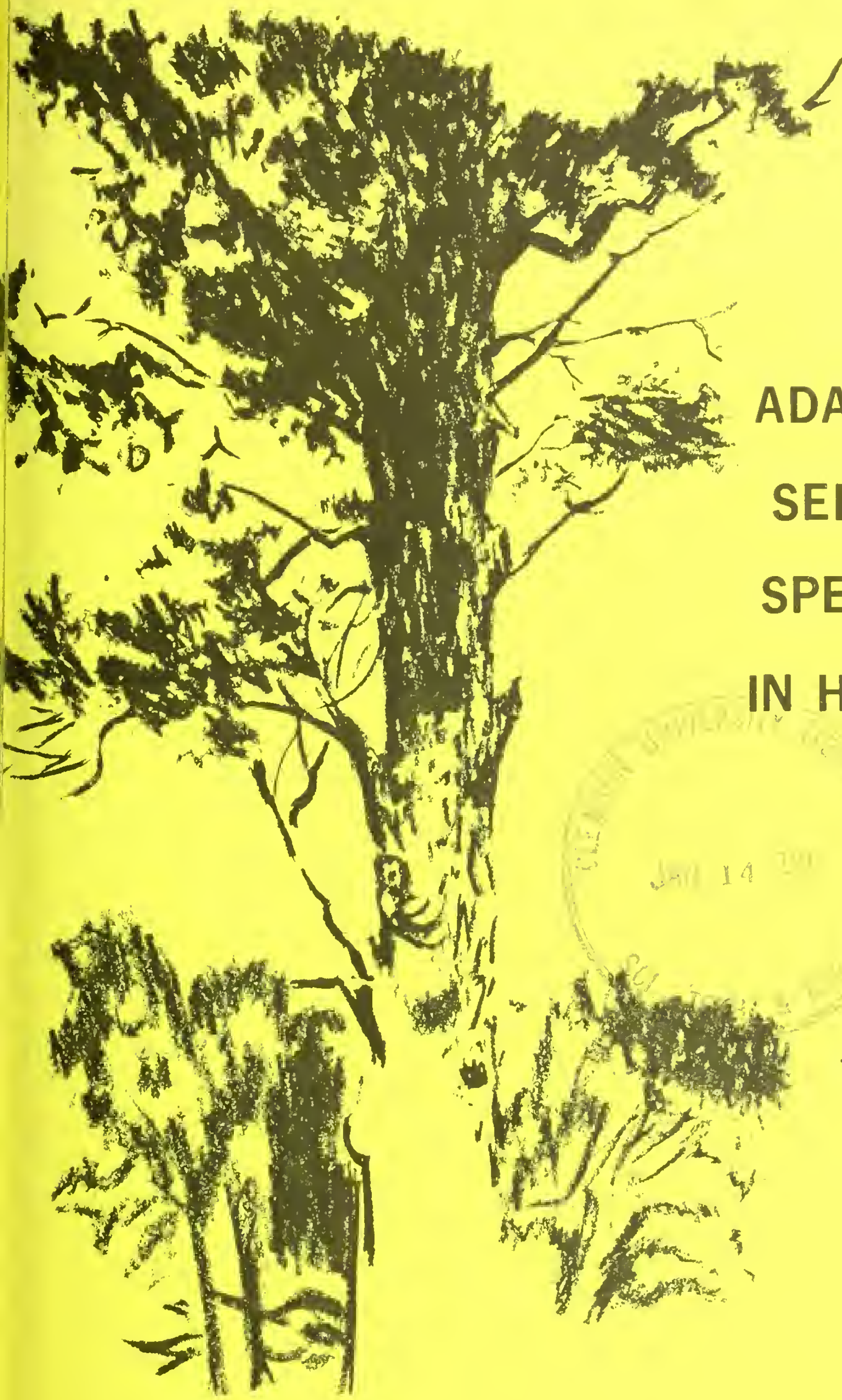
U.S. Forest Service, California Forest and Range Experiment Station.
1949. The timber stand and vegetation-soil maps of California. Berkeley, Calif. 15 p., illus.

U.S. Forest Service, California Forest and Range Experiment Station.
1954. Field manual, soil-vegetation surveys in California. Berkeley, Calif. 95 p., illus.

GPO 689—225/4405

PACIFIC SOUTHWEST
Forest and Range Experiment Station

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE P.O. BOX 245, BERKELEY, CALIFORNIA 94701



ADAPTABILITY OF SELECTED TREE SPECIES PLANTED IN HAWAII FORESTS

Robert E. Nelson

Thomas H. Schubert

USDA FOREST SERVICE RESOURCE BULLETIN PSW-14 /1976

Contents

The Authors

ROBERT E. NELSON heads the Station's Institute of Pacific Islands Forestry, headquartered in Honolulu, Hawaii. He joined the Forest Service in 1941, after earning a forestry degree at the University of California. He became field supervisor of the California State Cooperative Soil-Vegetation Survey in 1949. Since 1957, he has been in charge of the Station's Hawaii office. **THOMAS H. SCHUBERT**, formerly with the Station staff in Honolulu, Hawaii, is now in charge of research on artificial regeneration and plantation in silviculture, Institute of Tropical Forestry, Rio Piedras, Puerto Rico. Before assuming his current assignment, he was a member of the Forest Service's Timber Management Research Staff in Washington, D.C. He earned a forestry degree at New York State College of Forestry (1953), and M.F. (1955) and Ph.D. (1959) degrees at Harvard University.

ACKNOWLEDGMENT

Staff members of the Hawaii Division of Forestry assisted in the field appraisal work. We particularly thank L. W. Bryan, Allen W. Duval, Karl K. Korte, and Max F. Landgraf, District Foresters, for their assistance in helping locate specific plantings in the field. R. Sidney Boone, Stanley B. Carpenter, George B. Richmond, and Roger G. Skolmen, Research Foresters, U.S. Forest Service, contributed materially to the gathering of information in the field.

U.S. Forest Service research in Hawaii
is conducted in cooperation with
Division of Forestry
Hawaii Department of Land and Natural Resources

Many tree species have been introduced into Hawaii from around the world (Bryan and Walker 1962, Hillebrand 1965, St. John 1973). Trial introductions of new species for various forestry purposes began in the 19th century and are still continuing. Walker (1887), Judd (1915), Lyon (1929), Zschokke (1930), Bryan (1947), and Whitesell (1971, 1974), among others, have reported on some of the tree adaptability trials of government agencies and private organizations. But generally, adequate follow-up appraisals of the adaptability of species to the planting sites have not been performed, or at least have not been documented.

Nelson (1965) compiled available information about plantings made by the Hawaii Division of Forestry between 1908 and 1960. This new research developed listings of the species planted, the locations of plantings, and the number of seedlings and dates of plantings. The purpose was to provide a general tabular reference on forest tree species introduced to Hawaii, and to guide field appraisals of selected tree species already introduced on forest sites.

The present report summarizes appraisals of the adaptability of selected species. The appraisals are based on field observations and measurements, and seek to evaluate adaptability, growth, and form. Information on 31 species is presented in tabular form (p. 13), and the Species Notes provide additional comment on each species' characteristics, including its value as sawtimber and its flowering and fruiting habit. Recommendations for further research are also given.

THE HAWAII SETTING

The characteristics of sites in the Hawaiian Islands, as related to growth of trees and other plants, are markedly varied. These islands, lying in the tropical latitudes of the north central Pacific Ocean, have a mild year-round climate that is strongly affected, however, by the mountainous terrain (Armstrong 1973). Mountains rise to 13,784 feet (4201 m) on one island, to 10,012 feet (3052 m) on another, and to more than 1000 feet (305 m) on all the other main islands. Average annual rainfall ranges from less than 10 inches (250 mm) at some leeward locations to greater than 400 inches (10,000 mm) at other locations. The average temperature at sea level is about 75° F (24° C), decreasing about 3° F (1.7° C) per 1000-foot (305-m) increase in elevation above sea level.

The great diversity of physiographic conditions found in the 4.1 million acres (1.66 million ha) of land in Hawaii includes 190 soil series. All 10 orders of soils recognized in the National Cooperative Soil Survey are represented in Hawaii (Foote and others 1972, Sato and others 1973). Thus, there are many kinds of sites for tree growth, and growing conditions differ markedly within short distances.

Some 800 tree species have been planted throughout the islands, on a wide variety of forest sites, by the Hawaii Division of Forestry (Nelson 1965). Although some native Hawaiian species were planted, most of these were slow growing and difficult to establish on the eroded areas that made up some of the major areas needing reforestation. Therefore, planting was done primarily with exotic tree species. Many were tested through the years, with emphasis on those useful for protecting watersheds. Only recently has much attention been paid to timber-producing potential. The search for suitable species to grow on different sites in Hawaii continues.

STUDY METHODS

Data on tree planting work done by the Division of Forestry up to 1960 were organized by species name and by locations of plantings. From limited literature review and firsthand knowledge, each listed species was tentatively rated for probable silvical adaptability in Hawaii and for its potential to yield wood products. These preliminary "value" ratings of about 800 species, as well as information on location and number of trees planted, provided the basis for screening the lists, and 60 species were selected for field appraisal.

Plans were to appraise the growth of a given species at 10 locations representing diverse growing conditions, if there were that many plantings. When a planting was located in the field, information on tree stand, and site attributes was recorded:

Tree attributes: Diameter, height, form, crown width, defects, and merchantability potential.

Stand attributes: Species composition, spacing, basal area, density, damage, and presence of regeneration.

Site attributes: Elevation, precipitation, aspect, slope, soil depth, soil drainage, land use, mapped soil series, and competing vegetation.

Field appraisal work was mostly conducted between 1964 and 1968. Locating the plantings in the field proved to be unexpectedly difficult. The planting records usually mentioned only the forest reserve, which might encompass many square miles. All of the seedlings recorded as planted at one time were not necessarily planted at one site, or in a single block. Some were scattered throughout the areas designated. Even with the aid of local forestry personnel who in some instances had helped plant the trees, relocation success was less than 50 percent.

RESULTS

Although field appraisal efforts did not yield as much information as initially anticipated, the findings are helpful. Data (p. 13) from field examination of plantings of 31 species were summarized (*table 1*). Location of plantings appraised is given to the nearest second of latitude and longitude to aid those wishing to see them.

Even though large numbers of seedlings of most species were planted, specific recommendations can be made for very few species on the basis of the appraisal results. Only one, *Juglans nigra,* is considered not adapted to Hawaii. Several are apparently useful only for ornament or protective cover. The adaptability of nine, *Albizia falcataria, Araucaria columnaris, Eucalyptus deglupta, Fraxinus uhdei, Grevillea robusta, Sequoia sempervirens, Swietenia macrophylla, Swietenia mahagoni,* and *Toona ciliata* var. *australis,* is sufficiently established to support recommendations on the general site conditions they require in Hawaii. Research is now needed to determine the cultural practices that will produce the best growth and form of these species. For more than half the 31 species examined, however, further site trials are needed before a final decision concerning their adaptability in Hawaii can be made.

Our inability to readily apply the results of the study points up the critical importance of keeping complete records of trials of exotic species. Accurate locational information would have made it possible for us to find a much greater percentage of the plantings, or at least to verify that they had not survived. Detailed records of planting stock condition, planting techniques, weather at time of planting and during the establishment period, and postplanting maintenance treatments, would have made it possible to deduce with some degree of certainty whether failure or poor performance was caused by one or more of these factors, or by lack of species adaptation. Much more information might thus have been gained from the many plantings made between 1908 and 1960.

SPECIES NOTES

ACACIA MELANOXYLON R. B. (Leguminosae)[1]

Blackwood acacia is indigenous to southeastern Australia, on a wide range of sites. There it develops best in cool rain forest types and grows to heights of more than 120 feet (37 m). In Australia, the wood is considered highly attractive for cabinet and furniture uses; it closely resembles Hawaiian koa (*Acacia koa*).

Thirty plantings are recorded—on Kauai, Oahu, and Maui—totaling some 17,000 seedlings. The earliest planting, of 100 seedlings, was made in 1919 in the Papalolalola Forest Reserve, Kauai. Eight plantings were examined.

Blackwood acacia is well adapted to relatively cool, moist sites in Hawaii. Growth rates have been generally moderate. Some trees have attained heights of over 90 feet (27 m) and diameters breast high of over 20 inches (50 cm) in about 30 years. Although some trees were of excellent form for sawtimber, many were only fair or poor in form because of lateral branching, fluting of trunk, and spiral grain. Root suckering was common. Flowering was observed in April.

Further trials are needed in moist sites at elevations of 2000 to 4000 feet (610 to 1220 m). Equally or more important, research is needed in genetic tree improvement and on the effect of stand density on tree growth and quality.

References: Albert 1908, Australia Dep. Natl. Dev. 1962, Francis 1951, Streets 1962.

AGATHIS AUSTRALIS Salisb. (Pinaceae)

New Zealand kauri is indigenous to North Island, New Zealand, where it occurs over a wide range of growing conditions. There it reaches heights of 80 to 120 or even 150 feet (24 to 46 m), with long, clear boles and trunk diameters to 7 feet (2.1 m), or even larger. New Zealand kauri wood is recognized worldwide as excellent for many uses, including construction and furniture.

The four plantings recorded, totaling some 850 seedlings, were made on Oahu during 1920 to 1924.

---

[1] Family designations in this report are based on Dalla Torre and Harms 1900-1907.

Only one planting was located for appraisal. Growth had been generally slow but dominant trees were of excellent form for sawtimber. Fruiting was noted in October. Coppicing was also noted.

This species may offer considerable potential for forestry uses in Hawaii. Further adaptability trials are needed on different sites, especially at elevations above 2000 feet (610 m).

References: Hinds and Reid 1957, Parham 1964, Streets 1962.

AGATHIS ROBUSTA F. M. Bail. (Pinaceae)

Australian kauri or **Queensland kauri** is indigenous to areas in the vicinity of Maryborough and on Fraser Island, Queensland, Australia. There it occurs as a dominant in some rain forests, attaining heights of more than 140 feet (43 m). The wood is attractive and highly valued for cabinetry and millwork.

Eleven plantings are recorded from 1921 to 1958–on Oahu, Maui, and Hawaii–but totaling only 231 seedlings. Only one small planting was located for appraisal.

Growth had been slow, although tree form was excellent. Fruiting was not noted on these trees although fruiting has been noted on street trees in Hilo and Honolulu.

As this species may offer considerable potential for forestry uses in Hawaii, further trials are needed on different soils.

References: Australia Dep. Natl. Dev. 1962, Bryan 1947, Francis 1951, Lanner 1966, Parham 1964, Streets 1962.

AGATHIS VITIENSIS (Seem.) Drake. (Pinaceae)

Fijian kauri or **dakua** is indigenous in the rain forests of the Fiji Islands, but is now common only in the interior of the main islands. There, trees reach heights up to 100 feet (30 m) and have straight trunks with diameters to 6 feet (1.8 m). The wood has excellent properties for a wide range of uses including furniture, craft items, and face veneer.

Eleven plantings are recorded from 1951 to 1954–on Kauai, Oahu, and Hawaii–totaling some 600 seedlings. Only two plantings were located for appraisal.

Survival was good in both plantings. The growth and form of the trees planted in the Waiakea Forest Reserve on Hawaii indicated that this species holds promise for high rainfall sites. Cones were observed on one tree.

Further trials are needed at low and medium elevations on moist sites.

References: Fiji Dep. For. 1968, Parham 1964.

ALBIZIA FALCATARIA Fosberg (Leguminosae)

Molucca albizzia or **batai** is indigenous to the Moluccas and New Guinea. In the rain forest climate, early height growth often exceeds 15 feet (4.6 m) per year, but maximum heights are seldom more than 100 feet (30 m). The tree has a broad crown and is said to be shortlived. The wood is pale brown, light in weight, and moderately soft and weak. It is considered a general utility wood for uses not requiring high strength, a hard surface, or fine finish.

More than 80 plantings are recorded–on Kauai, Oahu, Lanai, Maui, and Hawaii–totaling some 138,000 seedlings. The earliest record of planting noted in this survey was of 64 seedlings in Kalihi Valley, Honolulu Forest Reserve, in 1925. Nineteen plantings were examined.

Molucca albizzia was found to be well adapted to many different soils from near sea level to at least 1600 feet (488 m) elevation. Survival and growth were inferior, however, on exposed sites or shallow rocky soils where annual rainfall is less than 50 inches (1270 mm). Annual height growth sometimes exceeded 20 feet (6 m) during the first few years after planting. Dominant trees in stands from 25 to 40 years old were about 100 feet (30 m) tall and broad crowned. Form was responsive to spacing. Long, clear main boles had developed at spacings of about 12 feet (3.7 m). Trees in more open stands had shorter main boles. Merchantable lengths of over 64 feet (20 m) were common in the better stands.

Molucca albizzia produces abundant seed, and natural regeneration was observed in and near many plantings. The species is a pest in some areas.

Further trials to determine the adaptability of this species to different sites are probably not needed, although its adaptability to sites above 1600 feet (488 m) is not known. Research is needed to determine the effect of stand density on growth, form, and log quality.

References: Byran 1947, Gerhards 1966, Parham 1964, Peters and Lutz 1966, Richards 1957, Streets 1962, Walters 1971.

ALNUS NEPALENSIS Don. (Betulaceae)

Nepal alder is indigenous throughout the Himalaya region and upper Burma at elevations from 3000 to 9000 feet (900 to 2700 m). On moist sites there, trees in natural stands grow rapidly to heights of 80 to 100 feet (24 to 30 m) with diameters up to 2½ feet (76 cm). This species invades disturbed ground and provides rapid protection from erosion. The wood is considered an easily worked utility wood.

Thirty-five plantings are recorded between 1930 and 1960—on Oahu, Molokai, Maui, and Hawaii—totaling some 43,000 seedlings. The earliest planting, not located in this study, was in 1930 in the Waiahole Forest Reserve, Oahu. Two stands established in the Kohala Mountains on Hawaii were examined and a few trees were observed at other locations.

Nepal alder was found to be well adapted to cool, moist, and very wet sites, at elevations above 2000 feet (610 m). Some trees had attained heights of more than 100 feet (30 m) and diameters of 24 inches (60 cm) in about 25 years on the very wet, foggy sites in the Kohala Mountains. Merchantable log lengths of 32 to 48 feet (10 to 15 m) were common, although many stems had sweep and persistent branches. On some sites windfall was common.

Nepal alder produces viable seed and natural regeneration has been observed.

Further trials are needed to determine the adaptability of Nepal alder to moist and wet sites at elevations above 3500 feet (1070 m). This species is not wind hardy and should not be planted on exposed sites or to enhance recreation areas. Research is also needed to determine the effect of stand density on growth, form, and log quality.

References: Bryan 1947, Gerhards 1964, Peters and Lutz 1966, Streets 1962, Troup 1921, Whitesell and Isherwood 1971.

ARAUCARIA COLUMNARIS (Forst.) Hook. (Pinaceae)

Columnar araucaria or **Cook's araucaria** is indigenous to New Caledonia and the Isle of Pines, where it grows to heights of over 130 feet (40 m). The wood is reported to have properties similar to *A. heterophylla* and *A. cunninghamii* which are excellent for many uses.

Fifty-three plantings are recorded between 1917 and 1960—on Kauai, Oahu, Maui, and Hawaii—totaling some 22,000 seedlings.[2] The earliest recorded plantings were in Manoa Valley, Oahu. Trees at eight locations were examined.

The species was found to be well adapted on a wide range of sites to above 2000 feet (610 m). Many trees attained heights of 80 feet (24 m) in about 40 years and some were over 100 feet (30 m) tall. Diameters breast high of measured dominant trees about 40 years old ranged from 13 to 24 inches (33 to 61 cm). There were few heavy branches and little forking to affect merchantable length, but persistent whorls of small limbs on nearly the entire bole adversely affected log quality.

Cook's araucaria produces viable seeds in Hawaii. Fruiting is much more abundant in some years than others. Cones ripen and dehisce in late summer or early fall (August to October).

Natural regeneration was found in and adjacent to most plantings examined. Exceptions were the wet site on the island of Hawaii, where no flowering or fruiting was noted, and the dry sites at Lualualei where fruiting was noted but no seedlings were seen.

Further site adaptability trials are probably not needed. However, as this species has considerable potential for use in Hawaii, research in cultural methods is needed to develop prescriptions for seedling production, planting methods, fertilizers, and weed control on different sites, and the effects of stand density, thinning, and pruning on growth and log quality. Research should include determining relationships between growth rates and site factors such as soil and elevation.

Cook's araucaria has potential for much greater use for Christmas trees, windbreaks, recreation site enhancement, landscape plantings, and timber. Litter production in older, dense stands seems to be ideal to protect the soil from erosion in the absence of understory vegetation.

References: Bryan 1947, Gerhards 1967, Neal 1965, Ntima 1968, Streets 1962.

ARAUCARIA CUNNINGHAMII Sweet. (Pinaceae)

Hoop pine is indigenous to New Guinea and to the coastal ranges of Queensland and northern New

[2] Differentiation between *A. columnaris* (Syn. *A. cookii* R. Br.) and *A. heterophylla* (Syn. *A. excelsa* R. Br.) may not have been consistent in the planting records. Probably some of the many plantings recorded as *A. heterophylla*, a species not included in this appraisal, are in fact *A. columnaris*.

South Wales. It occurs from near sea level to 8000 feet (2438 m) elevation in New Guinea and to 3000 feet (914 m) in Australia. In its native habitats it is a large tree, commonly attaining heights of over 150 feet (46 m) and diameters of over 4 feet (122 cm). Mature trees have clear boles yielding timber of excellent working qualities and useful for many purposes.

Thirteen plantings are recorded between 1929 and 1959—on Kauai, Oahu, Molokai, and Hawaii—totaling some 8600 seedlings. Observations and measurements of trees in two plantings located showed that growth had been slow and the trees are of low vigor.

As hoop pine may be a valuable species for various forestry purposes in Hawaii, further trials on a wider range of sites are needed.

References: Australia Dep. Natl. Dev. 1962, Bryan 1947, Francis 1951, Neal 1965, Ntima 1968, Streets 1962.

BRACHYCHITON ACERIFOLIUM F. Muell. (Sterculiaceae)

Flame tree is indigenous to the coastal rain forests of New South Wales and Queensland, Australia. There it grows to heights of 120 feet (37 m) and stem diameters of 3 feet (91 cm). It is reported to grow well on sites suited for macadamia nut (*Macadamia integrifolia*) trees. The pale-colored wood is very soft and suitable only for plywood corestock or other products where strength and natural durability are not important. Flame tree is reported to be an attractive ornamental and shade tree. It has been successfully introduced to some areas of Africa.

Twenty-nine plantings are recorded, between 1921 and 1957—on Oahu, Molokai, Maui, and Hawaii—totaling some 4100 seedlings. Only one planting was located for this appraisal—a single tree planted in 1953. It was of poor vigor and form. Although flame tree may be suited for ornamental plantings in Hawaii, forest plantings are not recommended.

References: Francis 1951, Neal 1965, Streets 1962.

CALLITRIS CALCARATA A. Cunn. ex Mirb. (Pinaceae)

Black cypress-pine is indigenous to Australia, occurring in Queensland, New South Wales, and Victoria, where it reaches heights to 80 feet (24 m) and diameters to 18 inches (46 cm). The dark, attractive wood finishes well and is valued for furniture, paneling, and trim work. It is also durable and termite resistant and is useful for posts and poles.

Seven plantings are recorded between 1933 and 1959—on Kauai, Maui, and Hawaii—totaling about 4500 seedlings. Only one planting was located for appraisal. This planting, on Maui in 1949, was of 4245 seedlings. Survival was fair, but growth of the best trees was only moderate. Continuing mortality indicated that the species is not adapted to the moderately moist site. Fruit was noted in November, but no flowers or reproduction.

Further adaptability trials are needed on drier or higher sites, as this species offers potential for ornamental use as well as timber.

References: Bryan 1947, Streets 1962.

CALLITRIS GLAUCA R. Br. (Pinaceae)

White cypress-pine is indigenous to Australia, occurring over a wide range of inland areas with annual rainfall from 14 to 28 inches (360 to 710 mm). There it commonly attains heights of 70 feet (21 m), or on the better sites, grows to 100 feet (30 m) with diameters to 3 feet (91 cm). The yellow-to-brown wood is reported to be of moderate strength and brittle. It is highly resistant to termites and useful for poles, posts, and construction lumber.

Eleven plantings are recorded between 1931 and 1957—on Oahu, Maui, and Hawaii—totaling some 1300 seedlings. The earliest plantings, in 1931, consisted of six seedlings planted in the Waihou Spring Forest Reserve, Maui, and six seedlings planted in the Kohala Forest Reserve, Hawaii. Only two plantings were located for appraisal.

Growth was slow and vigor low on a wet site, but much better on a rocky slope under lower rainfall. Tree form indicated good potential as sawtimber, although limbs were retained on the bole. Fruiting was noted in October at the drier location.

This species should be tested on sites more nearly like its native habitat, that is, drier sites from 1000 to 4000 feet (305 to 1220 m) elevation and avoiding wet, heavy-textured soils. It has potential as an ornamental and for watershed protection and timber production on drier sites.

References: Australia Dep. Natl. Dev. 1962, Bryan 1947, Streets 1962.

CALOPHYLLUM BRASILIENSE Camb. (Guttiferae)

Maria is native to the moist forest areas of Puerto Rico, and with its geographic varieties, is widely distributed throughout the West Indies and adjacent continental areas. There it grows to heights of over 65 feet (20 m) and diameters of 18 inches (46 cm) or more. Maria is commonly planted as an ornamental or shade tree. It is reported to be readily regenerated by direct seeding and to be adapted to degraded sites. The wood is attractive, resembling mahogany, but is more difficult to process.

Eight plantings are recorded—all on Maui between 1929 and 1932—totaling 295 seedlings. Only one planting was located for this appraisal. Dominant trees 34 years old were about 40 to 55 feet (12 to 17 m) tall and less than 15 inches (38 cm) diameter breast height. Short stature and crooked or forked boles indicated their potential for sawtimber was poor on this extremely wet site.

Trees were not flowering in June, but there were fruit and natural seedling regeneration. Some root and stem suckers were seen on windfalls.

Further tests of Maria are needed on different sites, especially to determine its adaptability to degraded sites. Before such tests are made, species identity should be confirmed.

References: Little and Wadsworth 1964, Neal 1965.

CASTANOSPERMUM AUSTRALE A. Cunn. (Leguminosae)

Moreton-Bay-chestnut is indigenous to New South Wales and Queensland, Australia, occurring in coastal rain forests and as far as 100 miles (161 km) inland. In its native habitats it is a large tree, reaching 130 feet (40 m) in height and 4 feet (122 cm) in stem diameter. The dark brown timber is considered one of the most attractive cabinet woods of Australia.

Twenty-four plantings are recorded between 1927 and 1957—on Kauai, Oahu, Maui, and Hawaii—totaling some 1200 seedlings. Only one planting was located for this appraisal, in the Ewa Forest Reserve, Oahu.

Survival was poor. Only three plants were seen, out of some 413 reported planted in 1927. Growth of surviving plants had been very slow, indicating the species is not adapted to that site. A large, vigorous specimen over 50 years old, growing as a yard tree in Kukuihaele, and the rapid growth of trees planted in 1967 in an experimental plot above Paauilo, island of Hawaii, are evidence that the species may be adapted to some moist sites in Hawaii. The tree at Kukuihaele produces viable seed. Flowering was observed in October.

Further trials are needed on moist, well-drained sites.

References: Francis 1951, Streets 1962.

CEDRELA ODORATA L. (Meliaceae)

Spanish-cedar is indigenous in lowland wet forests of tropical America—West Indies to Trinidad and Tobago; and Mexico, Ecuador, Peru, Brazil, and the Guianas. There, on good sites it is a large tree, reaching heights of more than 120 feet (37 m) and stem diameters of over 4 feet (122 cm). The wood is valued for its excellent working qualities and is used for high quality furniture, cabinetry, aromatic chests, trim, veneer, and general construction.

Thirty-two plantings are recorded between 1924 and 1959—on Kauai, Oahu, Molokai, Maui, and Hawaii—totaling more than 26,000 seedlings. The earliest planting was of 200 seedlings in Makiki Valley, Oahu. Only .two plantings were located for this appraisal.

Survival rate was low on these sites but growth of surviving trees had been generally good. Dominant trees in the 41-year-old stand in Makiki Valley were more than 80 feet (24 m) tall with stem diameters greater than 2 feet (61 cm). Trees examined in the planting on Maui had similar growth rates. Trees in Hawaii have produced viable seed.

Further trials of this species are needed, especially to test tree and stand development in well-stocked stands.

References: Bryan 1947, Lamb 1968, Little and Wadsworth 1964, Streets 1962.

CINNAMOMUM CAMPHORA (L.) Nees & Eberm. (Lauraceae)

Camphor-tree is indigenous to eastern Asia, including Taiwan and Japan. There it is reported to grow best at higher elevations in the tropics or subtropics, reaching heights of 100 feet (30 m) and diameters over 2 feet (61 cm) in forests in Taiwan. On most sites it is much smaller. It is commonly planted for windbreaks or as an ornamental and is also cultivated for production of camphor oil from leaves and twigs.

The fragrant wood is used for chests.

Twenty-seven plantings are recorded between 1919 and 1951—on Kauai, Oahu, and Maui—totaling some 3600 seedlings. Only one planting was relocated for this appraisal.

Survival was about 60 percent of some 500 trees planted. The 32-year-old trees were less than 50 feet (15 m) tall with stem diameters at breast height of up to 10 inches (25 cm). Some had straight stems but many were crooked or forked. No flowers, fruit, or seedlings were observed.

Camphor-tree should be tested further for adaptability and growth in Hawaii at elevations above 3000 feet (900 m) on moist, well-drained sites.

References: MacMillan 1952, Neal 1965, Streets 1962.

ENTEROLOBIUM CYCLOCARPUM (Jacq.) Gris. (Leguminosae)

Guanacaste or **earpod** is indigenous to the West Indies, Central America, and northern South America. There it is a fast-growing, large tree, reaching heights of 130 feet (40 m) and stem diameters over 6 feet (1.8 m). It is an attractive shade tree. The timber is suitable for furniture and general carpentry, closely resembling the wood of monkey-pod (*Pithecellobium saman* [Jacq.] Benth.).

Thirty-five plantings are recorded between 1923 and 1949—on Kauai, Oahu, Maui, and Hawaii—totaling some 16,000 seedlings. Four plantings were located for this appraisal, all on the island of Maui.

Survival was low in most plantings, but growth had been moderate to fast. Some 30-year-old trees measured were more than 100 feet (30 m) tall and had diameters at breast height greater than 3 feet (91 cm).

The potential for growing this timber tree in Hawaii should be determined by establishing well-stocked stands on moist deep soils where rainfall is greater than 70 inches (1780 mm).

References: Bryan 1962, Neal 1965, Rock 1920, Streets 1962.

EUCALYPTUS DEGLUPTA Blume (Myrtaceae)

Bagras eucalyptus is indigenous to New Guinea, New Britain, the Molucca Islands, and Mindanao in the Philippine Islands. It is a rain forest tree growing to heights of more than 200 feet (61 m) and diameters breast high of more than 6 feet (1.8 m). On well-drained alluvial soils early growth is extremely rapid. Bagras timber is lighter in weight than that of most eucalypts. The reddish-brown wood machines and seasons well and is useful for construction and cabinet work.

Bagras eucalyptus is an attractive tree and in recent years, has been used for landscaping in urban areas in Hawaii. Twenty-eight plantings are recorded between 1945 and 1958—on Kauai, Oahu, Molokai, Maui, and Hawaii—but totaling only about 4200 seedlings. Six plantings were examined.

Adaptability and growth were variable, depending on site conditions. Trees planted at low evelations on well-drained soils in areas of high rainfall had grown rapidly and developed long, clear boles. In one planting, some 13-year-old trees were 90 feet (27 m) tall and more than 12 inches (30 cm) d.b.h.

Intensive silvicultural research should be initiated with this species on moist, well-drained sites at low elevations in Hawaii. Its use for urban area landscaping should also be studied. Its rapid growth to large sizes on some sites may cause problems in urban areas.

References: Davidson 1973, Kraemer 1951, Penfold and Willis 1961, Streets 1962.

FLINDERSIA BRAYLEYANA F. Muell. (Rutaceae)

Queensland-maple is indigenous in the rain forests of Queensland, Australia. There it grows to 100 feet (30 m) tall and may have a stem diameter of over 4 feet (1.2 m). The attractive wood processes well and is highly valued and extensively used for fine furniture and cabinetry.

Twenty-one plantings are recorded, two in 1935 and the others between 1957 and 1960—on Oahu, Molokai, and Hawaii—totaling about 3800 seedlings. Three plantings were located for this appraisal.

Although survival and growth were variable, the rapid growth and good form of many individual trees indicated that Queensland-maple has good potential for timber production on a range of sites. On Oahu sites, dominant trees reached heights of over 70 feet (21 m) and diameters breast high of nearly 20 inches (50 cm) in 30 years. On the island of Hawaii, some 13-year-old trees were 80 feet (24 m) tall with diameters of 12 inches (30 cm).

Further experimental plantings of Queensland-maple should be made to determine the sites to which it is best adapted, and also to determine growth and development of well-stocked stands.

References: Burgan and Wong 1971, Francis 1951, Neal 1965, Streets 1962.

FRAXINUS UHDEI (Wenzig) Lingelsh. (Oleaceae)

Tropical ash is indigenous in Western and Southern Mexico and Guatemala. A medium-size tree there, it grows to 60 feet (18 m) in height and 16 inches (40 cm) in trunk diameter. It is reported to grow along stream banks. Tropical ash is a popular street and shade tree in Mexico City, Guadalajara, and elsewhere. The light-colored, yellowish wood is moderately heavy and strong and is well-suited to furniture and cabinet work. It does not have the toughness and strength required for tool handles.

More than 125 plantings of tropical ash are recorded between 1924 and 1960–on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii–totaling over 294,000 seedlings. The 14 plantings located for this appraisal included four on the island of Lanai which were not listed in the records surveyed. There is confusion about the identity of species in the *Fraxinus* plantings. Many were recorded as *F. americana* when planted, but botanists who have studied specimens indicate that the Hawaii plantings are probably all *F. uhdei.*

Tropical ash grew best in Hawaii on moist sites with well-drained soils at elevations between 1500 and 5000 feet (457 to 1524 m). Survival was low, growth slow, and form scrubby on relatively dry sites on ridges and side slopes on the island of Oahu. On Lanai island, under similar rainfall, but on alluvial soils, growth and form were better. Trees 37 years old reached 100 feet (30 m) in height and more than 2 feet (61 cm) in trunk diameter. The tendency for low forking, development of multiple stems, or lodging was a drawback in terms of potential timber production. Nevertheless, some young stands produced sawtimber at rates greater than 1000 board feet per acre (14 m^3 per ha) per year.

Tropical ash trees produce abundant viable seed in Hawaii and natural regeneration is occurring.

Further research is needed on the silvics of this species and the cultural practices needed for optimum stand development. Genetic tree improvement research should also be initiated.

References: Neal 1965, Pickford and LeBarron 1960, Standley and Williams 1969, Whitesell and others 1971, Youngs 1960.

GREVILLEA ROBUSTA A. Cunn. (Proteaceae)

Silk-oak is indigenous to the rain forests of Queensland and New South Wales, Australia, where it attains heights of 120 feet (37 m) and trunk diameters of 3 feet (91 cm). The attractive yellowish wood with distinctive ray pattern is valued for cabinetry. The tree has attractive foliage and flowers and is widely planted for shade and landscaping.

Two hundred and seventy plantings, totaling more than 2.2 million seedlings are recorded between 1910 and 1959–on Kauai, Oahu, Molokai, Maui, and Hawaii.

Silk-oak is adapted to a broad range of sites in Hawaii. It has become naturalized over thousands of acres, mostly below 1000 feet elevation. It grows moderately rapidly and attains fair form for sawtimber at elevations from near sea level to over 3000 feet (914 m) and under a range of annual rainfall from 35 inches (890 mm) to over 175 inches (4450 mm). Silk-oak is considered by some landowners to be a noxious weed on pasture lands.

Further research on the adaptability of silk-oak to various sites in Hawaii is probably not needed. However, research on silvicultural practices will be beneficial as this species has good potential for timber production.

References: Francis 1951, Nelson 1960, Streets 1962.

INTSIA BIJUGA (Colebr.) O. Kuntze (Leguminosae)

Ipil is indigenous over a wide area, from the coast of East Africa through Southern Asia, the Malay Archipelago, New Guinea, Fiji, and some other Pacific Islands. It is best adapted to areas just inland from the shoreline or to moist alluvial flats where it reaches heights up to 100 feet (30 m) and stem diameters up to 3 feet (91 cm). The reddish-brown, coarse-textured wood is very heavy but seasons well. Although the wood is not as easily worked as some hardwoods, its durability, high strength, and low shrinkage make it highly useful for flooring and special structural purposes.

Nine plantings are recorded between 1917 and 1947–on Oahu and Maui–totaling only 285 trees, however. None of these recorded plantings were located in this appraisal. The one planting found and appraised was on a slope, not typical of soils to which ipil is naturally adapted. Nevertheless, 30-year-old trees had grown to 86 feet (26 m) in height and 20 inches (51 cm) d.b.h.

The potential of this species in Hawaii should be tested by establishing well-stocked, experimental stands on moist, alluvial soils at elevations no higher than 1000 feet (305 m).

References: Fiji Dep. For. 1968, Kraemer 1951, Rock 1920, Streets 1962.

JUGLANS NIGRA L. (Juglandaceae)

Black walnut is indigenous to the Central and Eastern United States of America and Southeastern Canada. Best adapted to deep alluvial soils, it grows to over 100 feet (30 m) tall with stem diameters greater than 3 feet (91 cm). Black walnut wood is highly valued and is in great demand for furniture manufacture, paneling, and craftwood. The tree is also grown as an ornamental and for nuts.

Twenty plantings are recorded between 1932 and 1947–on Maui and Hawaii–totaling 1620 trees. Three plantings were located for this appraisal. Low survival, slow growth, and inferior form and vigor of trees indicated that black walnut is not adapted to Hawaii sites.

Reference: Harlow and Harrar 1937.

LAGERSTROMEIA SPECIOSA (L.) Pers. (Lythraceae)

Giant crapemyrtle or **queen flower** is indigenous to the India-Ceylon-Malayan region. It is a medium-size tree, attaining heights of about 50 feet (15 m). It has been widely planted as an ornamental because it provides a strikingly beautiful seasonal show of purplish blossoms. It is reported to grow best in moist low areas where annual rainfall exceeds 60 inches (1520 mm). Wood of giant crapemyrtle is hard and durable and is highly valued for special uses such as boat building.

Twenty-four forest plantings are recorded between 1926 and 1957–on Oahu, Molokai, Maui, and Hawaii–totaling about 5200 seedlings. Nearly 3600 of these were planted in 1937 in the Honouliuli Forest Reserve, Oahu, but were not found during this study. Two plantings were located for this appraisal, both on Maui. Survival of this species was not good on the sites planted and growth and form of surviving trees indicated it has little potential for timber. Any further tests should be confined to areas of deep, well-drained soils with annual rainfall of 50 to 100 inches (1250 to 2500 mm). Where it can be cared for, this species can be grown as an ornamental in Hawaii.

References: Little and Wadsworth 1964, MacMillan 1952, Neal 1965, Streets 1962.

PLATYMISCIUM STIPULARE Benth. (Leguminosae)

Roble is indigenous to Central and South America. It is reported to be a medium-to-large tree in native forests, and is an attractive ornamental, producing a profusion of yellow flowers. The wood is red, hard, and heavy, and is useful for furniture and other products.

Nineteen plantings are recorded between 1937 and 1959–on Oahu, Molokai, and Maui–totaling 5600 seedlings. More than half of these were planted in the Waianae Mountains, island of Oahu, in 1937. Four plantings were examined.

Adaptability of roble to Hawaii sites varied. Where survival was relatively high, growth had been moderate or slow and the form of the tree for timber was generally inferior. The largest trees measured were 29 years old, 60 to 80 feet (18 to 24 m) tall and 12 to 15 inches (30 to 38 cm) d.b.h.

More information about the microsites where these larger trees are growing would be useful to assess the potential for further trials of this species as an ornamental or as a timber tree.

References: Menninger 1962, Neal 1965, Record and Hess 1943, Rock 1920.

PODOCARPUS IMBRICATUS[3] Blume (Taxaceae)

Java podocarpus is indigenous to a broad trans-equatorial region of the Western Pacific, occurring from near sea level to nearly 10,000 feet (3000 m) elevation. Its growth is variable in its natural range but on some sites it grows to 150 feet (46 m) tall. It is considered a valuable timber species, the wood being used for furniture, construction, and carvings.

---

[3] Syn. *P. cupressina* R. Br.

Sixteen plantings totaling only 460 seedlings are recorded between 1924 and 1958, on Oahu, Molokai, and Hawaii. The earliest planting, of 10 seedlings, was at Puu Kauku on the island of Hawaii. Three plantings were relocated for this appraisal.

Growth of the trees in one planting, at 1700 feet (518 m) elevation and with an annual rainfall of about 200 inches (5000 mm), indicated that there is potential for this species as a timber tree in Hawaii. Although growth had been slow, averaging only 1 to 2 feet (30 to 60 cm) in height per year, the form of the trees was good. The species is reproducing naturally from seed in the vicinity of the planted trees. Appraisal of 22-year-old trees at a site at 5100 feet (1550 m) showed little potential for the species there. Java podocarpus also has potential for use in landscaping.

Further trials are needed on different soils. Trials should probably be restricted to sites below 4000 feet (1200 m) elevation.

References: MacMillan 1952, Parham 1964, Richmond 1965.

SEQUOIA SEMPERVIRENS (D. Don) Endl. (Pinaceae)

Redwood is indigenous to the coastal areas of northern California and the extreme southwest corner of Oregon. It occurs where annual rainfall is as low as 25 or as high as 122 inches (630 to 3100 mm), but it is restricted to areas having heavy summer fogs. On some alluvial bottomland sites, redwood trees attain heights greater than 300 feet (91 m). The tallest redwood on record is 368 feet (112 m), the tallest tree in the world. Redwood timber is lightweight, soft, easily worked and highly valued for its great durability. It is much preferred for siding, paneling, stakes, and posts where durability is important.

Eighty-four plantings are recorded between 1919 and 1960–on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii–totaling more than 130,000 seedlings. Nine plantings were examined.

On a few sites redwood plantings had high survival and moderately rapid growth. These were areas of well-drained soils lying above 3000 feet (914 m) elevation and having a high incidence of fog. On these sites, some trees reached heights greater than 110 feet (34 m) and were more than 30 inches (76 cm) d.b.h. after 37 years. Experience has demonstrated that seedling establishment is difficult because of competition of other vegetation, as growth of planted seedlings is slow for the first few years.

Redwood is an excellent species for forestation of moist, mid-elevation sites in Hawaii, especially areas where fog is frequent.

Reference: USDA Forest Service 1965.

SWIETENIA MACROPHYLLA King (Meliaceae)

Honduras mahogany is indigenous to tropical America from Southern Mexico to Northern South America. It is a large forest tree attaining heights to 130 feet (40 m) and diameters of 6 feet (1.8 m) on deep, fertile, alluvial soils. Because Honduras mahogany timber is one of the most highly valued cabinet woods of the world, this species has been planted extensively in many tropical areas, to develop timber resources and also as an ornamental or shade tree.

Thirty-four plantings are recorded between 1928 and 1960–on Oahu, Molokai, Maui, and Hawaii–totaling about 7000 seedlings. Three plantings were located for this appraisal.

Survival was good and growth had been moderately rapid. In one planting, on Oahu, trees were up to 88 feet (27 m) in height and up to 20 inches (51 cm) in trunk diameter after 22 years. At the Fleming planting on Maui, 30-year-old trees were as much as 85 feet (26 m) tall. Some trees exceeded 14 inches (36 cm) in diameter. Natural regeneration was present in this stand.

Honduras mahogany appears to be well adapted to moist sites in Hawaii. It should be planted only on deep well-drained soils of lower slopes or valley bottoms. Plantings should probably be restricted to areas below 1000 feet (300 m) elevation.

Research is needed to develop specific knowledge about the site requirements and cultural practices needed to grow this valuable tree for timber crops in Hawaii.

References: Bryan 1947, Little and Wadsworth 1964, Record and Hess 1943, Streets 1962.

SWIETENIA MAHAGONI Jacq. (Meliaceae)

West Indies mahogany is indigenous to southern Florida, the Bahamas, Cuba, Jamaica, and Hispaniola. It is a medium-size to large forest tree, attaining heights to 100 feet (30 m) and diameters greater than 4 feet (1.2 m) on the best sites. West Indies mahogany is considered to be the world's premier cabinet wood. It has been planted in many tropical areas of the world to develop timber resources. It is also an attractive ornamental and shade tree.

Thirty-seven plantings are recorded between 1918 and 1958–on Kauai, Oahu, Molokai, Maui, and Hawaii-totaling nearly 12,000 seedlings. Six plantings were located for this appraisal.

The high variation in survival and growth of trees in different plantings probably indicates that West Indies mahogany is not adapted to most sites in Hawaii. Nevertheless, it can be recommended for forest plantings on deep, well-drained soils at elevations below 1000 feet (300 m) where annual rainfall is greater than 60 inches (1520 mm). It is also recommended as a street or shade tree.

Research should determine what specific site factors and cultural practices are required to grow this valuable tree for timber crops in Hawaii.

References: Bryan 1947, Little and Wadsworth 1964, Record and Hess 1943, Streets 1962.

TABEBUIA DONNELL-SMITHII Rose (Bignoniaceae)

Primavera is indigenous to Southern Mexico and Central America. It is a large tree, growing to heights of 80 feet (24 m) or more and trunk diameters of 4 feet (1.2 m). Primavera is also called gold tree because of its show of yellow flowers. Its striking beauty in bloom makes it a highly desired tree for landscaping. Primavera is also prized for its timber. The light yellowish or pale brown wood is useful for furniture, cabinetry, and paneling, being easily worked and finished and dimensionally stable. Commercial supplies are scarce.

Eighteen plantings totaling only 1200 seedlings are recorded between 1923 and 1958, on Kauai, Oahu, Maui, and Hawaii. Only one small planting was relocated for this study.

Trees in this planting had heights to 55 feet (17 m) and stem diameters to 20 inches (51 cm) at 40 years of age. Because these trees were planted at wide spacing and were open-grown, appraisal of timber production potential is not possible. Primavera trees are growing quite well as street plantings and landscape specimens at many low elevation locations in Hawaii.

Further trials should be conducted to determine the adaptability of primavera to higher elevations, on typical forest sites.

References: Kukachka 1958, Neal 1965, Record and Hess 1943.

TERMINALIA MYRIOCARPA Heurick & Meull.-Arg. (Combretaceae)

Jhalna is indigenous to India. It is reported to be a large tree there, having long, clear boles with diameters to 6 feet (1.8 m). It is an attractive tree when in flower or fruit. Jhalna wood is dark brown, finishes well and is classified as a medium-weight utility wood.

Sixty-four plantings totaling over 26,000 seedlings are recorded between 1928 and 1958, on Kauai, Oahu, Maui, and Hawaii. Eight plantings were located for this appraisal.

Survival was good and growth rate had been moderate on a broad range of relatively moist sites. But the form of the tree for timber production was generally inferior. Although occasional trees were single-stemmed, most were multistemmed from near the base. Jhalna was regenerating naturally and in some instances this "second-growth" had better form than the planted trees.

Jhalna has no special known attributes for extensive forestry use in Hawaii. Further trials with the species are not recommended. However, as it is attractive and seems adapted to a broad range of moist sites, it should be considered a candidate for some forestry plantings and for landscaping.

References: Brandis 1907, Bryan 1947, Neal 1965, Sekhar and Sharma 1966.

TOONA CILIATA var. *AUSTRALIS* (F. Muell.) C. DC. (Meliaceae)

Australian toon is a large tree indigenous to New South Wales and Queensland, Australia. There, in the coastal rain forests, it attains heights to 140 feet (43 m) and trunk diameters to 6 feet (1.8 m). The reddish brown wood is attractive and is reported to be durable. It seasons well, and is highly valued for manufacture of furniture, cabinetry, and paneling.

More than 170 plantings are recorded between 1917 and 1960–on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii–totaling some 190,000 seedlings. Trees at 17 locations were appraised.

Australian toon is adapted to a wide range of sites. On widely differing sites, trees were more than 100 feet (30 m) tall and had stem diameters greater than 2 feet (61 cm) after 30 to 40 years. Adaptability and growth were good on sites up to 3500 feet (1067 m) elevation. A planting at 5300 feet (1615 m) indicated the species is not adapted to that elevation. Australian toon should not be planted on soils having poor drainage. In areas where annual rainfall is less than 50 inches (1270 mm), plantings should be made only on deep soils or lower-slope topographic positions.

Australian toon produces viable seed in Hawaii. Natural regeneration is occurring in and adjacent to many plantings examined.

Further site adaptability trials are probably not needed. However, as this species has considerable potential for enhancing the forest resources in Hawaii, research in cultural methods is needed. Prescriptions need to be developed for seedling production, planting methods, fertilizers, and weed control on widely different sites. Research should include detailed investigations of the relationship of growth rates to soil and other site factors. And the effects of stand density, thinning, and pruning on timber yield and quality should be determined.

References: Bryan 1947, Francis 1951, Pickford and LeBarron 1960, Streets 1962, Wick and Burgan 1970, Wick and others 1971, Youngs 1960.

Index of Common Names of Trees

Table 1--Forest tree plantings appraised for species adaptability to Hawaii

Species and location of plantings appraised (lat. N, long. W)[1]			Elevation	Rainfall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
			Feet	Inches						
Acacia melanoxylon (30 P, 17,000 S; K,O,M; 1919-51)										
Kauai	22°08'00"	159°38'40"	3600	45	Kokee	ca.1935	4 acres	Good	Moderate	Fair
	22°08'12"	159°38'35"	3700	70	Kunuweia	ca.1935	4 acres	Good	Moderate	Fair
	22°07'55"	159°39'05"	3600	60	Kokee	ca.1950	4 acres	Good	Moderate	Fair
	22°07'30"	159°39'55"	3600	55	Kokee	ca.1935	4 acres	Fair	Moderate	Fair
Maui	20°41'02"	156°20'15"	5200	45	Kaipoioi	1936	462	Poor	Moderate	Fair
	20°50'55"	156°17'12"	2100	75	Olinda	1932	1,000	Fair	Moderate	Inferior
	20°48'18"	156°17'11"	3700	55	Olinda	1934	106	Fair	Moderate	Fair
	20°46'37"	156°13'55"	6400	75	Kaipoioi	1951	2,520	Poor	Slow	Inferior
Agathis australis (4 P, 850 S; O; 1920-24)										
Oahu	21°28'10"	157°52'10"	300	90	Waikane	1920	780	Fair	Slow	Excellent
Agathis robusta (11 P, 231 S; O,M,H; 1921-58)										
Hawaii	19°40'10"	155°04'00"	100	150	Papai	1936	67	Good	Slow	Excellent
Agathis vitiensis (11 P, 593 S; K,O,H; 1951-54)										
Hawaii	19°37'31"	155°08'25"	1500	200	Kiloa	1952	468	Good	Moderate	Excellent
	20°04'44"	155°33'30"	2200	80	Honokaa	1952	24	Good	Slow	Excellent

(Continued)

[1]Planting history is given after species name: P = number of plantings, S = number of seedlings; initials indicate islands: H--Hawaii; K--Kauai L--Lanai; M--Maui; Mo--Molokai; O--Oahu.

[2]Soil classification determined from soil maps (Foote and others 1972, Sato and others 1973). It must be recognized that soil at the spot where the trees were growing may not be the soil as mapped, because of mapping intensity and inclusions.

[3]Where ca. appears, records indicate that this date is probably within 5 years of the actual date.

[4]Adaptability is shown as follows: Good = Greater than 70 percent survival or stocking; Fair = 40 to 70 percent survival or stocking; Poor = Less than 40 percent survival or stocking.

[5]Height growth is shown as follows: Fast = Greater than 5 feet per year; Moderate = 2 to 5 feet per year; Slow = Less than 2 feet per year.

[6]Form is shown as follows: Excellent = Long straight clean bole; Fair = Will likely produce more than one sawlog but has heavy or persistent branches; Inferior = Will not likely produce more than one sawlog or is extremely limby or forked.

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]			Eleva-tion	Rain-fall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
			Feet	Inches						
Albizia falcataria (84 P, 138,000 S; K,O,L,M,H; 1925-55)										
Oahu	21°18'50"	157°46'55"	600	60	Lolekaa	1950	150	Good	Fast	Fair
	21°20'15"	157°49'10"	1600	120	Cinder land	1948	?	Good	Moderate	Fair
	21°29'25"	158°05'50"	1000	40	Kawaihapai	ca.1930	4 acres	Good	Moderate	Excellent
	21°23'40"	157°54'20"	800	50	Manana	ca.1940	4 acres	Fair	Slow	Inferior
	21°21'55"	157°48'25"	1100	130	Lolekaa	ca.1930	4 acres	Fair	Slow	Inferior
Hawaii	19°26'49"	154°51'32"	100	80	Aa lava flow	1951	600 seed	Fair	Moderate	Fair to inferior
	19°38'24"	155°08'50"	1500	200	Kiloa ext.	1948	122	Good	Fast	Fair
	20°11'20"	155°46'15"	1600	110	Niulii	ca.1925	4 acres	Good	Moderate	Inferior
	20°11'00"	155°46'10"	1600	110	Kehena	ca.1925	4 acres	Good	Fast	Excellent
Kauai	21°57'35"	159°31'50"	1400	60	Pooku	ca.1925	4 acres	Good	Fast	Fair
	21°56'50"	159°32'15"	1100	45	Kapaa	ca.1930	4 acres	Good	Moderate	Fair
	21°57'00"	159°31'55"	1600	50	Pooku	ca.1930	4 acres	Good	Fast	Fair
	21°56'50"	159°31'46"	1300	50	Kalapa	ca.1930	4 acres	Good	Fast	Excellent
	21°56'55"	159°30'15"	900	75	Rough broken land	ca.1930	4 acres	Good	Fast	Fair to excellent
	21°55'50"	159°26'30"	400	65	Hihimanu	ca.1925	4 acres	Good	Fast	Fair
	22°10'35"	159°23'30"	700	60	Pooku	ca.1925	4 acres	Good	Fast	Excellent
	22°04'12"	159°21'05"	600	60	Hanamaulu	ca.1940	4 acres	Fair	Moderate	Fair
	22°04'28"	159°21'13"	400	60	Hanamaulu	ca.1940	4 acres	Good	Fast	Fair
Maui	20°54'35"	156°31'15"	700	40	Rough mountainous	ca.1925	4 acres	Fair	Moderate to fast	Fair to excellent
Alnus nepalensis (35 P, 43,050 S; O,Mo,M,H; 1930-60)										
Hawaii	20°02'57"	155°40'36"	3600	75	Kahua	1939	3,754	Fair	Moderate	Inferior
	20°03'50"	155°37'50"	3400	100	Kahua	1939	4 acres	Fair to good	Moderate to fast	Inferior to fair
Araucaria columnaris (53 P, 21,949 S; K,O,M,H; 1917-59)										
Hawaii	19°50'02"	155°08'45"	1600	250	Hydrol humic latosol	1923	130	Good	Moderate	Excellent

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]	Elevation	Rainfall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
	Feet	Inches						
Araucaria columnaris (continued)								
Oahu 21°27'20" 158°05'40"	2200	40	Tropohumults-Dystrandepts Assoc.	1927	1,132	Poor	Slow	Fair
21°37'30" 157°57'10"	900	90	Kapaa	1929	175	Good	Moderate	Fair
21°39'20" 158°01'05"	700	60	Kapaa	1926	306	Good	Moderate	Fair
21°28'10" 157°52'05"	300	90	Waikane	1921	1,000	Good	Moderate	Excellent
21°28'20" 157°51'55"	500	90	Waikane	1927	3,885	Good	Moderate	Excellent
21°28'20" 158°07'00"	1100	40	Lualualei	1920	492	Good	Slow	Fair
21°25'35" 158°06'45"	1000	32	Stony land	1927	2,338	Good	Slow	Fair
Araucaria cunninghamii (13 P, 8637 S; K,O,Mo,H; 1929-59)								
Oahu 21°18'55" 157°48'15"	800	45	Manana	1932	280	Poor	Slow to moderate	Fair
Kauai 21°57'08" 159°31'20"	1400	50	Kalapa	1934	1,000+	Good	Slow	Fair
Brachychiton acerifolium (29 P, 4119 S; O,Mo,M,H; 1921-57)								
Maui 20°52'57" 156°11'58"	700	190	Kailua	1953	?	Poor	Slow	Fair
Callitris calcarata (7 P, 4514 S; K,M,H; 1933-59)								
Maui 20°54'52" 156°16'00"	500	80	Pauwela	1949	4,245	Poor	Moderate	Fair
Callitris glauca (11 P, 1290 S; O,M,H; 1931-57)								
Oahu 21°23'50" 157°54'15"	700	70	Rockland	1935	116	Fair	Moderate	Fair
21°19'35" 157°48'00"	500	125	Rough mountainous	1933	124	Fair to poor	Slow	Fair
Calophyllum brasiliense (8 P, 295 S; M; 1929-32)								
Maui 20°51'52" 156°10'19"	360	240	Rough mountainous	1931	68	Poor to fair	Slow	Inferior
Castanospermum australe (24 P, 1187 S; K,O,M,H; 1927-57)								
Oahu 21°23'45" 157°54'05"	900	70	Rough mountainous	1927	473	Poor	Slow	Inferior

(Continued)

For footnotes see ge 13.

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]	Elevation	Rainfall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and (stocking)[4]	Height growth[5]	Form[6]
	Feet	Inches						
Cedrela odorata (32 P, 26,000 S; K,O,Mo,M,H; 1924-59)								
Oahu 21°19'10" 157°49'40"	500	75	Rockland	1924	200	Fair	Moderate	Fair
Maui 20°50'53" 156°16'56"	2100	120	Honomanu-Amalu Assoc.	1932	1,065	Fair	Moderate	Fair
Cinnamomum camphora (27 P, 3631 S; K,O,M; 1919-51)								
Oahu 21°19'30" 157°47'50"	600	125	Rough mountainous	1933	532	Fair	Slow	Inferior
Enterolobium cyclocarpum (35 P, 16,067 S; K,O,M,H; 1923-49)								
Maui 20°53'01" 156°13'32"	1200	90	Honomanu-Amalu Assoc.	1936	1,040	Fair	Fast	Fair
20°53'36" 156°14'58"	1200	170	Rough broken land	1936	1,272	Poor	Moderate	Inferior
20°52'34" 156°12'38"	1200	170	Honomanu-Amalu Assoc.	1937	323	Fair to poor	Moderate	Fair
20°52'31" 156°11'18"	600	200	Honomanu-Amalu Assoc.	1954	6	Good	Fast	Excellent
Eucalyptus deglupta (28 P, 4192 S; K,O,Mo,M,H; 1945-58)								
Oahu 21°19'25" 157°47'00"	900	110	Lolekaa	1953	?	Good	Moderate to fast	Fair
21°19'25" 157°47'05"	800	110	Kawaihapai	1953	?	Good	Fast	Excellent
Maui 20°53'00" 156°12'15"	900	150	Rough mountainous	1954	?	Good	Fast	Excellent
20°53'10" 156°12'30"	900	150	Kailua	1954	?	Fair	Moderate	Fair
Hawaii 20°04'44" 155°33'30"	2200	90	Honokaa	1950	3	Good	Moderate	Excellent
19°38'30" 155°05'47"	800	200	Hapai	1957	126	Good	Fast	Excellent
Flindersia brayleyana (21 P, 3815 S; O,Mo,H; 1935-60)								
Oahu 21°19'50" 157°48'55"	1400	110	Tantalus	1935	270	Fair	Moderate	Fair
21°23'55" 157°54'10"	900	65	Rough mountainous	1935	289	Good	Moderate	Fair
Hawaii 19°38'30" 155°05'47"	800	200	Papai	1957	180	Good	Fast	Fair to excellent

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]			Elevation	Rainfall	Soil mapping unit[2]	Year planted	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
			Feet	Inches						
Fraxinus uhdei (125+ P, 294,000+ S; K,O,Mo,L,M,H; 1924-60)										
Oahu	21°39'10"	158°01'50"	700	55	Paumalu	1935	?	Poor	Slow	Inferior
	21°27'25"	158°05'35"	1800	40	Tropohumults-Dystrandepts Assoc.	1928	3,364	Fair	Slow	Inferior
	21°18'35"	157°48'10"	1000	45	Manana	1932	925	Poor	Slow	Inferior
	21°23'40"	157°53'05"	1100	70	Rough mountainous	1934	3,780	Fair	Slow	Inferior
	21°24'15"	157°53'55"	1200	85	Rough mountainous	1929	1,005	Fair	Slow	Inferior
Lanai	20°50'30"	156°54'30"	1700	40	Koele	1935	4 acres	Good	Moderate	Fair
	20°50'25"	156°54'30"	1800	40	Koele	1935	4 acres	Fair	Moderate	Fair
	20°49'30"	156°54'10"	1700	40	Koele	1935	4 acres	Good	Moderate	Fair
	20°50'15"	156°54'30"	2000	40	Koele	1935	4 acres	Good	Moderate	Fair
Hawaii	19°29'45"	155°52'20"	3200	80	Kealakekua	1929	1,000	Good	Moderate	Fair
	19°55'00"	155°19'00"	5000	125	Puu Oo	1918	?	Good	Moderate	Fair
Maui	20°48'23"	156°17'10"	3700	55	Olinda	1928	628	Good	Moderate	Fair to excellent
	20°51'01"	156°16'57"	2100	120	Alluvium	1928	614	Good	Moderate	Fair
	20°41'25"	156°20'15"	5200	40	Kaipoioi	1936	?	Good	Slow	Inferior
Grevillea robusta (270 P, 2,242,000 S; K,O,Mo,M,H; 1910-59)										
Oahu	21°25'55"	158°05'00"	1300	35	Tropohumults-Dystrandepts Assoc.	1938	36,000	Good	Moderate	Fair
	21°23'50"	157°54'10"	700	70	Rough mountainous	1927	5,174	Fair	Moderate	Fair
	21°21'30"	157°48'42"	1100	130	Lolekaa	1930	4 acres	Good	Moderate	Fair
	21°23'55"	158°06'00"	2100	35	Tropohumults-Dystrandepts Assoc.	1940	4 acres	Good	Slow	Fair
	21°27'30"	158°05'00"	1900	40	Tropohumults-Dystrandepts Assoc.	1940	4 acres	Good	Moderate	Fair
	21°27'15"	158°05'00"	1700	40	Manana	1940	4 acres	Good	Moderate	Fair
Maui	20°52'26"	156°11'30"	1200	200	Honomanu-Amalu Assoc.	1935	5,568	Fair	Moderate	Fair
	20°48'33"	156°05'37"	800	170	Hana	1939	1,035	Good	Moderate	Fair
	20°48'23"	156°17'12"	3600	55	Rough broken land	1928	214	Poor	Slow	Inferior
	21°01'20"	156°37'14"	200	35	Rough broken land	1949	?	Fair	Slow	Inferior
	20°46'40"	156°14'55"	6900	50	Laumaia	1910	25	Poor	Slow	Inferior

(Continued)

For footnotes see page 13.

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]	Eleva-tion	Rain-fall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
	Feet	Inches						
Grevillea robusta (continued)								
Hawaii 19°20'19" 155°27'16"	3500	60	Kapapala	1930	2,208	Fair	Moderate	Fair
19°57'54" 155°16'50"	2000	150	Kiloa	1925	700	Good	Moderate	Fair
19°59'55" 155°20'30"	2200	130	Honokaa	1930	4 acres	Good	Moderate	Fair
19°38'00" 155°08'15"	1300	175	Kiloa	1930	4 acres	Good	Moderate	Fair
19°46'40" 155°50'45"	2900	35	Rockland	1930	4 acres	Good	Moderate	Fair
19°45'10" 155°58'30"	2000	40	Kaimu	1930	4 acres	Good	Moderate	Fair
20°04'45" 155°34'37"	2300	100	Honokaa	1930	4 acres	Good	Moderate	Fair
20°02'07" 155°26'55"	2400	100	Honokaa	1930	4 acres	Good	Moderate	Fair
Intsia bijuga (9 P, 285 S; O,M; 1917-47)								
Maui 21°00'18" 156°36'27"	200	75	Rough broken land	1935	?	Fair	Moderate	Fair to inferior
Juglans nigra (20 P, 1620 S; M,H; 1932-47)								
Maui 20°48'22" 156°17'00"	3600	55	Olinda	1941	10	Poor	Slow	Inferior
Hawaii 19°51'51" 155°18'25"	5300	120	Piihonua	1942	141	Poor	Slow	Inferior
19°40'27" 155°52'47"	6200	40	Rough broken land	1942	209	Poor	Slow	Inferior
Lagerstroemia speciosa (24 P, 5200 S; O,Mo,M,H; 1926-57)								
Maui 20°51'36" 156°10'49"	200	90	Rough mountainous	1935	27	Poor	Slow	Inferior
20°51'08" 156°10'27"	100	240	Rough mountainous	1954	25	Poor	Slow	Inferior
Platymiscium stipulare (19 P, 5600 S; O,Mo,M; 1937-59)								
Oahu 21°24'25" 158°06'45"	1200	30	Stony land	1937	2,625	Good	Slow	Inferior
21°18'35" 157°45'20"	1000	50	Helemano	1953	133	Poor	Slow	Inferior
21°27'25" 158°05'25"	1800	40	Tropohumults-Dystrandepts Assoc.	1937	1,028	Fair	Moderate	Fair to inferior
Maui 20°53'21" 156°15'56"	500	80	Kailua	1949	720	Poor	Slow	Inferior
Podocarpus imbricatus (16 P, 460 S; O,Mo,H; 1924-58)								
Hawaii 19°55'26" 155°20'14"	5100	80	Hanipoe	1942	47	Poor	Slow	Inferior
20°04'44" 155°33'30"	2200	80	Honokaa	1950	38	Fair	Slow	Good
19°50'05" 155°09'30"	1700	200	Rough broken land	1924	10	Good	Slow	Good

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]	Elevation	Rainfall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
	Feet	Inches						
Sequoia sempervirens (84 p, 130,000 S; K,O,Mo,L,M,H; 1919-60)								
Kauai 22°08'10" 159°38'35"	3500	60	Kokee	1930	4 acres	Good	Moderate	Fair
Lanai 20°48'55" 156°52'00"	3200	40	Kahanui	1956	3,000	Poor	Slow	Fair
Maui 20°42'05" 156°18'57"	6400	35	Laumaia	1956	12	Good	Slow	Fair
20°48'17" 156°17'04"	3800	55	Olinda	1930	3,490	Poor	Slow	Fair
20°41'28" 156°20'04"	5600	40	Kaipoioi	1930	18,567	Good	Moderate	Excellent
20°50'59" 156°17'10"	2100	100	Rockland	1932	1,153	Poor	Slow	Inferior
Hawaii 19°57'25" 155°20'14"	4000	80	Maile	1927	3,604	Poor	Slow	Fair
19°29'32" 155°52'12"	3100	110	Kealakekua	1927	1,000	Good	Moderate	Excellent
20°01'43" 155°26'36"	2500	70	Honokaa	1929	41	Poor	Slow	Fair
Swietenia macrophylla (34 P, 7000 S; O,Mo,M,H; 1928-60)								
Oahu 21°34'45" 158°00'55"	700	80	Alluvium	1944	258	Good	Moderate	Fair
Maui 21°00'28" 156°36'28"	200	140	Rough mountainous	1935	?	Good	Moderate	Fair
Hawaii 19°40'00" 155°04'00"	100	150	Papai	1936	161	Good	Slow	Fair
Swietenia mahagoni (37 P, 11,626 S; K,O,Mo,M,H; 1918-58)								
Oahu 21°39'30" 158°00'55"	800	60	Kapaa	1926	250	Poor	Slow	Inferior
21°39'25" 158°00'55"	700	60	Kapaa	1921-1923	850	Good	Slow	Inferior
21°24'15" 157°53'55"	1200	85	Rough mountainous	1927	199	Poor	Slow	Inferior
21°19'20" 157°49'45"	500	75	Kaena	1918	1,484	Good	Slow	Fair to inferior
21°26'00" 158°06'20"	1000	35	Stony land	1926	1,238	Poor	Slow	Inferior
Maui 20°50'47" 156°16'34"	2400	100	Kailua	1928	2,203	Poor	Slow	Inferior
Tabebuia donnell-smithii (18 P 1237 S; K,O,M,H; 1923-58)								
Hawaii 19°12'35" 155°28'20"	700	40	Naalehu	1924	18	Fair	Slow (18+)	Inferior and fair

(Continued)

For footnotes see page 13.

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W)[1]			Elevation	Rainfall	Soil mapping unit[2]	Year planted[3]	Number seedlings planted	Adaptability (survival and stocking)[4]	Height growth[5]	Form[6]
			Feet	Inches						
Terminalia myriocarpa (64 P, 26,339 S; K,O,M,H; 1928-58)										
Oahu	21°22'10"	157°50'30"	500	110	Lolekaa	1950	170	Fair	Moderate	Inferior
	21°20'15"	157°49'15"	1500	120	Tantalus	1948	205	Fair	Moderate	Fair
Hawaii	19°38'30"	155°56'13"	2300	90	Honaunau	1929	258	Fair	Moderate	Inferior and fair
	19°38'00"	155°09'13"	1500	200	Keei	1929	180	Fair	Moderate	Inferior
	19°57'20"	155°20'16"	4000	80	Maile	1936	2,921	Good	Slow	Inferior
	20°04'40"	155°33'30"	2200	70	Honokaa	1945	418	Good	Moderate	Inferior
	20°11'25"	155°46'35"	1600	75	Niulii	1929	454	Good	Moderate	Inferior
	19°29'28"	155°52'03"	3200	110	Kealakekua	1936	500	Good	Moderate	Inferior
Toona ciliata var. *australis* (178 P, 190,000 S; K,O,Mo,L,M,H; 1917-60)										
Oahu	21°24'00"	157°54'10"	1000	65	Rough mountainous	1924	260	Poor	Slow	Inferior
	21°31'25"	157°58'55"	1100	60	Rough mountainous	1929	710	Fair	Moderate	Fair
	21°39'15"	158°01'00"	800	60	Kapaa	1920-1924	3,364	Poor	Slow	Inferior
	21°34'45"	158°00'55"	700	80	Alluvium	1943-1944	235	Good	Moderate	Fair
	21°19'10"	157°49'40"	500	75	Rockland	1920-1924	2,380	Fair	Slow	Fair
	21°19'30"	157°49'05"	1300	100	Tantalus	1921-1922	664	Fair	Moderate	Excellent
	21°20'00"	157°48'55"	1500	120	Tantalus	1926	385	Fair	Moderate	Fair
Lanai	20°49'45"	156°54'15"	1800	40	Rough mountainous	1935	?	Fair	Moderate	Fair
	20°50'55"	156°54'25"	1700	40	Koele-Badland complex	1935	?	Good	Moderate	Excellent
Maui	20°48'23"	156°17'16"	3500	50	Olinda	1928	2,450	Good	Moderate	Fair
	20°50'57"	156°16'50"	2100	120	Alluvium	1928	75	Poor	Slow	Inferior
	20°50'54"	156°16'54"	2100	120	Kailua	1928	?	Fair	Moderate	Fair
	20°41'25"	156°20'15"	5300	40	Kaipoioi	1936	?	Poor	Slow	Inferior
	20°49'03"	156°08'28"	1400	240	Rough mountainous	1936	18,040	Fair	Moderate	Fair
Hawaii	20°02'31"	155°36'23"	2900	60	Maile	1923	300+	Fair	Moderate	Excellent
	19°29'30"	155°52'03"	3200	110	Kealakekua	1935	500	Good	Moderate	Excellent
	19°38'28"	155°55'59"	2600	90	Honaunau	1928	609	Good	Moderate	Fair

For footnotes see page 13.

Literature Cited

Albert, Federico.
1908. Australian blackwood–*Acacia melanoxylon,* 20 p. [Trans. from Spanish.] USDA Forest Service

Armstrong, R. Warwick.
1973. Atlas of Hawaii, 222 p., illus. The Univ. Press of Hawaii, Honolulu.

Australia Department of National Development, Forestry and Timber Bureau.
1962. Forest trees of Australia. 2nd ed. 230 p., illus. Aust. Dep. Natl. Dev., Canberra.

Brandis, Dietrich.
1907. Indian trees, 767 p., illus. Archibald Constable and Co., London.

Bryan, L. W.
1947. Twenty-five years of forestry work on the island of Hawaii. Hawaiian Planters' Record 51(1):1-80, illus.

Bryan, L. W., and Clyde M. Walker.
1962. (Rev. 1966). A provisional check list of some common native and introduced forest plants in Hawaii. USDA Forest Serv. Misc. Paper 69, 34 p. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Burgan, Robert E., and W. H. C. Wong, Jr.
1971. Species trials at the Waiakea Arboretum–tree measurements in 1970. USDA Forest Serv. Res. Note PSW-240, 6 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Dalla Torre, C. G. de, and H. Harms.
1900-1907. Genera siphonogamarum ad systema englerianum conscripta, 568 p. G. Engelman, Leipsig.

Davidson, John.
1973. A description of *Eucalyptus deglupta.* Tropical Forestry Res. Note SR-7, 23 p., illus. Dep. of Forests, Papua, New Guinea.

Fiji Department of Forestry.
1968. Some timbers of Fiji. Fiji Dep. For., Suva. 59 p., illus.

Foote, Donald E., Elmer L. Hill, and Sakuichi Nakamura.
1972. Soil survey of the islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii. USDA Soil Conserv. Serv. in coop. with Univ. of Hawaii Agric. Exp. Stn., 232 p., illus. U.S. Govt. Print. Office, Washington, D.C.

Francis, W. D.
1951. Australian rain-forest trees. Forestry and Timber Bur., Commonw. of Australia. 469 p., illus. Halstead Press Pty, Sydney.

Gerhards, C. C.
1964. Limited evaluation of physical and mechanical properties of Nepal alder grown in Hawaii. USDA Forest Serv. Res. Note FPL-036, 4 p., illus. Forest Prod. Lab., Madison, Wis

Gerhards, C. C.
1966. Physical and mechanical properties of *Molucca albizzia* grown in Hawaii. USDA Forest Serv. Res. Paper FPL-55, 8 p., illus. Forest Prod. Lab., Madison, Wis.

Gerhards, C. C.
1967. Physical and mechanical properties of Norfolk-Island-pine grown in Hawaii. USDA Forest Serv. Res. Paper FPL-73, 8 p., illus. Forest Prod. Lab., Madison, Wis.

Harlow, William M., and Ellwood S. Harrar.
1937. Textbook of dendrology. 527 p., illus. McGraw-Hill Book Co., New York.

Hillebrand, W. F.
1965. Flora of the Hawaiian Islands: a description of phanerograms and vascular cryptograms. 673 p. Hafner Publ. Co., New York.

Hinds, H. V., and J. S. Reid.
1957. Forest trees and timbers of New Zealand. New Zealand Forest Serv. Bull. No. 12, 211 p., illus. Hutcheson, Bowman, and Stewart, New Zealand.

Judd, C. S.
1915. Report of Committee on Forestry, Hawaiian Sugar Planters' Assoc. p. 6-14.

Kraemer, J. Hugo.
1951. Trees of the Western Pacific Region, 436 p., illus. Tri-State Offset Co., Cincinnati, Ohio.

Kukachka, B. Francis.
1958. Primavera. USDA Forest Serv. Forest Prod. Lab. Report No. 2021, 7 p., illus. Forest Prod. Lab., Madison, Wis.

Lamb, A. F. A.
1968. Fast growing timber trees of the lowland tropics. No. 2. *Cedrela odorata.* Commonw. Forestry Inst., Dep. of Forestry, Univ. of Oxford, London. 46 p., illus.

Lanner, Ronald M.
1966. An unusual bisexual agathis cone. Pacific Sci. 20(3):382-383.

Little, Elbert L., Jr., and Frank H. Wadsworth.
1964. Common trees of Puerto Rico and the Virgin Islands. U.S. Dep. Agric., Agric. Handb. 249, 548 p., illus.

Lyon, H. L.
1929. Ten years in Hawaiian forestry. The Hawaiian Planters' Record 33(1):55-97, illus.

MacMillan, H. F.
1952. Tropical planting and gardening. 5th ed. 560 p., illus. Macmillan and Co., London.

Menninger, Edwin A.
1962. Flowering trees of the world. 1st ed. 336 p., illus. Hearthside Press, New York.

Neal, M.C.
1965. In gardens of Hawaii. Bernice P. Bishop Museum Spec. Publ. 50. 924 p., illus. Bishop Museum Press, Honolulu.

Nelson, R. E.
1960. Silk-oak in Hawaii . . . pest or potential timber? USDA Forest Serv. Misc. Paper No. 47, 5 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Nelson, R. E.
1965. A record of forest plantings in Hawaii. USDA Forest Serv. Resour. Bull. PSW-1, 18 p. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Ntima, O. O.
1968. Fast growing timber trees of the lowland tropics. No. 3, The Araucarias. Commonw. Forestry Inst., Dep. of Forestry, Univ. of Oxford, London. 139 p., illus.

Parham, J. W.
1964. Plants of the Fiji Islands. 353 p., illus. Government Press, Suva, Fiji.

Penfold, A. R., and J. L. Willis.
1961. The eucalypts. 551 p., illus. Leonard Hill Books, London; Interscience Publ., New York.

Peters, C. C., and J. F. Lutz.
1966. Some machining properties of two wood species grown in Hawaii–Molucca albizzia and Nepal alder. USDA Forest Serv. Res. Note FPL-0117, 10 p., illus. Forest Prod. Lab., Madison, Wis.

Pickford, G. D., and R. K. LeBarron.
1960. A study of forest plantations for timber production on the island of Hawaii. Tech. Paper No. 52, 17 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif. In coop. with Deps. Agric. and Conserv., State of Hawaii.

Record, Samuel J., and Robert W. Hess.
1943. Timbers of the new world. 640 p., illus. Yale Univ. Press, New Haven.

Richards, P. W.
1957. The tropical rain forest. 450 p., illus. Univ. Press, Cambridge, England.

Richmond, G. B.
1965. Naturalization of Java podocarpus in Hawaii rain forest. USDA Forest Serv. Res. Note PSW-76, 5 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Rock, Joseph F.
1920. The leguminous plants of Hawaii. Exp. Stn., Hawaiian Sugar Planters' Assoc., Honolulu. 234 p., illus.

St. John, Harold.
1973. List and summary of the flowering plants in the Hawaiian Islands. Pacific Tropical Botanical Garden, Kauai, Hawaii. 519 p., Cathay Press, Hong Kong.

Sato, Harry H., Warren Ikeda, and Robert Paeth.
1973. Soil survey of the island of Hawaii, State of Hawaii. USDA Soil Conserv. Serv. in coop. with Univ. of Hawaii Agric. Exp. Stn., 115 p., illus.

Sekhar, A. C., and R. S. Sharma.
1966. Comparative studies on mechanical properties of natural and plantation grown *Terminalia myriocarpa* (Hollock). Indian Forestry Bull., 6 p., Dehra Dun Forest Res. Inst.

Standley, Paul C., and Louis O. Williams.
1969. Flora of Guatemala. Fieldiana:Botany 24(4):266-269.

Streets, R. J.
1962. Exotic forest trees in the British Commonwealth. 765 p., illus. Oxford Univ. Press London.

Troup, R. S.
1921. The silviculture of Indian trees. 3 vols., 1195 p. Oxford Univ. Press, London. U.S. Department of Agriculture, Forest Service.

1965. Silvics of forest trees in the United States. U.S. Dep. Agric., Agric. Handb. 271, 762 p., illus. U.S. Govt. Print. Office, Washington, D.C.

Walker, Thomas R.
1887. Report of committee on forestry. Planters Month. (Hawaii) 6(11):531-533.

Walters, G. A.
1971. A species that grew too fast–*Albizia falcataria*. J. For. 69(3):168.

Whitesell, Craig D., and M. O. Isherwood, Jr.
1971. Adaptability of 14 tree species to two Hydrol Humic Latosol soils in Hawaii. USDA Forest Serv. Res. Note PSW-236, 5 p. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Whitesell, Craig D., Herbert L. Wick, and Nobuo Honda.
1971. Growth response of a thinned tropical ash stand in Hawaii . . . after 5 years. USDA Forest Serv. Res. Note PSW-227, 3 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Whitesell, Craig D.
1974. Planting trials of 10 Mexican pine species in Hawaii. USDA Forest Serv. Res. Paper PSW-103, 8 p. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Wick, Herbert L., and R. E. Burgan.
1970. A spacing trial in Australian toon. USDA Forest Serv. Res. Note PSW-220, 3 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Wick, Herbert L., R. E. Nelson, and L. K. Landgraf.
1971. Australian toon planted in Hawaii: tree quality, growth, and stocking. USDA Forest Serv. Res. Paper PSW-69, 10 p., illus. Pacific Southwest Forest and Range Exp. Stn., Berkeley, Calif.

Youngs, Robert L.
1960. Physical, mechanical and other properties of five Hawaiian woods. USDA Forest Serv. FPL Rep. No. 2191, 34 p., illus. Forest Prod. Lab., Madison, Wis.

Zschokke, Theodore C.
1930. A manual for tree planting in the Hawaiian Islands. 50 p., illus. Univ. of Hawaii Agric. Ext. Serv. Ext. Bull. 5, Honolulu.

☆U.S. GOVERNMENT PRINTING OFFICE: 1977 - 789-002/6511 9-II

30